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ENGINEERING:

An Illustrated Weekly Journal.

EDITED BY WILLIAM H. MAW AND ALEX. RICHARDSON.

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John H. Wilson & Co., Ltd., Birkenhead. See Illustrated Advertisement Page 100, Jan. 28.

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"Spencer-Hopwood" Patent Boilers. *See page 97, July 29.* Sole Makers: SPENCER-BONECOURT, LTD., 9266 Parliament Mansions, Victoria St., London, S.W. GOLD MEDAL-INVENTIONS EXHIBITION-AWARDED.

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E. J. Davis, M.I.Mech.E., Gas Engines Inspected, Tested and Reported Upon. Over 25 years' experience. Tel.: 736 and 737 Stratford. Wire: "Rapidising, London." —Great Eastern Road, Stratford, E. 15. 1794 'Phone—Holb. 541. Tele—Andrubo, Holb., London.

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Matthew Paul & Co., Ltd. LEVENFORD WORKS, Dumbarton, 9513 See Full Page Advt., page 67, July 22.

Steelwork Erectors. EWART WELLS AND CO., LTD., 104, High Holborn, London, W.C.1. Directors: THOS. W. ELLIS, HOBART SHAW. Telegrams: Ewastrucel, Westcent, London. Telephone: Holborn 4741. Our Speciality—RAILWAY BRIDGES AND OIL TANKS. Also at Chepstow and Avonmouth. B 264

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See Advt. Page 106, July 29. **Steam Hammers Power Hammers Steam and Friction Drop Stamps.** **B. & S. Massey, Ltd.,** 9140 MANCHESTER.

The Manchester Steam Users' Association.

For the prevention of Steam Boiler Explosions and for the attainment of Economy in the Application of Steam. 9, Mount Street, Manchester.

Chief Engineer: C. H. Strombyhr, M.I.C.H. Founded 1854 by Sir William Fairbairn.

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Finsbury Technical College.

(Leonard Street, City Road, E.C. 2.)

Dean for the Session 1921-22, Professor W. H. Roques, D.Sc., F.R.S.

The College provides for the Scientific Training of Students who desire to become Civil, Mechanical or Electrical Engineers, or Chemists.

A certificate of proficiency is awarded by the Institute to students who satisfactorily complete a Two Years Course of instruction; and the Diploma of the College is awarded to students who attend a Three Years Course and who pass the prescribed Examinations with distinction.

Candidates are required to pass an Entrance Examination in Mathematics and English, but the Matriculation Certificate of any British University and certain other qualifications are accepted by the Institute in lieu of the Entrance Examination. The Entrance Examination for the Session 1921-22 will be held on Tuesday, September 20th next. Applications for admission should be forwarded to the College not later than the 15th September, on forms to be obtained from the Registrar, Leonard Street, City Road, E.C.

The Programme of the College is under revision and will be issued in due course. R 576

University of Birmingham.

FACULTY OF SCIENCE.

ENGINEERING DEPARTMENTS.

I.—Mechanical Engineering.
Chance Professor: F. W. Burstall, M.Sc., M.A. (Cantab.), M.Inst.C.E., M.Inst.M.E.
Lecturer: R. C. Porter, M.Sc. (Vict.), A.M.Inst.C.E.
Demonstrator: S. J. Ellis, A.M.I.C.E.
Lecturer on Machine Design: F. H. Boden.
Assistant Lecturer on Machine Design: Henry Baker, B.Sc.

II.—Civil Engineering.
Beale Professor: Frederick C. Lea, M.Sc. D.Sc. (Lond.), A.M.I.C.E., A.R.C.S.
Lecturers: R. C. Panton, M.Sc.
R. H. Stradling, B.Sc., A.M.I.C.E.
H. W. Coultas, B.Sc.
Lecturer on Town Planning: W. Haywood.

III.—Electrical Engineering.
Professor: William Cramp, D.Sc.
Lecturer: B. J. Kipps, M.Sc., M.Inst.E.E.
Assistant Lecturers and Demonstrators: O. R. Randall, B.Sc.
H. Vickars, M.Eng.
G. M. Harvey, B.Eng.

The FULL COURSES EXTEND OVER FOUR YEARS, and students who enter after Matriculation and pass successfully the examinations at the end of each year will BE ENTITLED TO THE DEGREE OF BACHELOR OF SCIENCE in Engineering.

The SESSION 1921-22 COMMENCES on OCTOBER 3rd, 1921.

For detailed Syllabus of the Faculty, with full particulars of University Regulations, Lecture and Laboratory Courses, Fees, etc., apply to the SECRETARY. R 620

University College of Swansea.

(A Constituent College of the University of Wales.)

APPLIED SCIENCE DEPARTMENTS.

Metallurgy.
Professor:—C. A. Edwards, D.Sc. (Manchester).
Lecturer:—H. L. Cox, M.Sc. (Wales and Birmingham).
Assistant Lecturers:—A. L. Norbury, M.Sc. (Manchester); L. B. Pfeil, A.R.S.M.

Engineering.
Professor:—Frederic Bacon, M.A. (Cantab), A.M. Inst.C.E., M.I.Mech.E., M.I.E.E.
Lecturer in Electrical Engineering:—R. G. Isaacs, B.Sc. (Lond.), A.M.I.E.E.
Lecturer in Civil Engineering:—J. Lloyd Davies, B.Sc. (Lond.).
Demonstrator:—J. Selwyn Caswell.

The College offers a number of exceptional advantages to students who aim at entering upon professional careers in Metallurgy or in Engineering. It is situated in the heart of an industrial area, which includes a large number of works of very varied character, and presents an unrivalled variety of metallurgical practice. The manufacturers of the district, who contribute largely to the support of the College, give the staff and the students of the Applied Science Departments every access to the works, and the managers, engineers and technical officials co-operate with the staff of the College in making visits to Works of practical educational value to the students.

Courses of study are provided (1) for the B.Sc Degree of the University of Wales in (a) Metallurgy, (b) Civil Engineering, (c) Mechanical Engineering, (d) Electrical Engineering, and (2) for Diplomas of the College in (a) Metallurgy, (b) Civil Engineering, (c) Mechanical Engineering, (d) Electrical Engineering.

Persons who are not desirous of studying for degrees or diplomas may attend selected College Classes, provided they satisfy the authorities of the College that they are qualified to benefit by such classes.

Several Open Entrance Scholarships, each of the annual value of £50, with free tuition, and the South Wales Institute of Engineers' Scholarship in Engineering of the annual value of £70, with free tuition, will be offered for competition in September, 1921.

Particulars concerning admission to the College, and of the Entrance Scholarships, may be obtained from the undersigned.

EDWIN DREW, Registrar.
University College Offices,
Dumbarton House,
Bryn-y-mor Crescent, Swansea. R 494

Inst.C.E. Exams.—Successes

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Inst. C.E., I. Mech. E., B.Sc.,

and all Engineering Examinations.—Mr. G. P. Knowles, B.Sc., M.E.E., A.M.Inst.C.E., F.S.I., M.R.San.I., PREPARES CANDIDATES personally or by correspondence. Hundreds of successes. Courses may commence at any time.—39, Victoria St., Westminster, S.W. Tel. 4780 Victoria. 9491

TENDERS.

STONE URBAN DISTRICT COUNCIL.

TO ENGINE BUILDERS.

The above Council invite

Tenders for the Provision and

Erection of a STEAM PUMPING ENGINE, of about 30 B.HP., at their Waterworks.

Specifications and Form of Tender may be obtained from Mr. R. C. Frain, M.I.C.E., 39, Albion Street, Hanley, Stoke-on-Trent, on payment of £1, which will be returned on receipt of bona-fide Tender.

Tenders, endorsed "Tender for Engine," must be received by me, the undersigned, on or before Saturday, 20th August.

The Council do not bind themselves to accept the lowest or any Tender.

CHARLES H. MATTHEWS,
Clerk to the Council.
Westbridge House, Stone, Staffs.
30th July, 1921. R 636

COUNTY BOROUGH OF WALLASEY.

NEW BRIGHTON LANDING STAGE RECONSTRUCTION.

The Corporation of Wallasey invite

Tenders for the Supply and

Delivery of 12 Cast Iron COMPRESSORS, with steel tie rods and plates, for the attachment of Landing Stage Moorings for the above, in accordance with the detailed Plans and Specification prepared by Messrs. Wilton & Bell, Consulting Civil Engineers, Westminster Chambers, 1, Crosshall Street, Liverpool. Plans and Specification may be seen at Messrs. Wilton & Bell's Offices by appointment, and Contractors desiring to obtain copies of the Plans may do so on payment of £1 1s. Tenders on the Form of Tender provided must be delivered to the undersigned, in a Sealed Envelope, endorsed "Tender for New Brighton Landing Stage Compressors," not later than Noon, Saturday, September 17th, 1921.

GEO. LIVSEY,
Town Clerk.
Town Hall, Wallasey,
2nd August, 1921, R 647

COUNTY BOROUGH OF WALLASEY.

SEACOMBE FERRY IMPROVEMENTS.

The Corporation of Wallasey invite

Tenders for the carrying out

of that portion of the above work denominated Work "A," which comprises a New FLOATING GOODS LANDING STAGE, approximately 230 ft. in length and 80 ft. in breadth, and Works in connection therewith, in accordance with the detailed Plans and Specification of Messrs. Wilton & Bell, Consulting Civil Engineers, Westminster Chambers, 1, Crosshall Street, Liverpool, the Engineers for the work, at whose offices copies of the Plans and Specification may be seen. Contractors desiring to obtain copies of Plans and Specification may do so on payment of £5 5s. Tenders on the Form of Tender provided must be delivered to the undersigned, in a Sealed Envelope, endorsed "Tender for Seacombe Ferry Improvements, Work 'A,'" not later than 12 noon Saturday, October 15th, 1921.

GEO. LIVSEY,
Town Clerk.
Town Hall, Wallasey.
2nd August, 1921. R 646

BOMBAY, BARODA AND CENTRAL INDIA RAILWAY COMPANY.

The Directors are prepared to receive up to Noon on Wednesday, 24th August,

Tenders for the Supply of—

CLASS A.
1. DUPLICATE PARTS FOR LOCOMOTIVES, CARRIAGES AND WAGONS (BUFFERS AND BRAKE BEAMS).
2. COPPER FIREBOX PLATES.
3. SCREW COUPLINGS.
4. HELICAL AND VOLUTE SPRINGS.
5. LAMINATED AND ELLIPTICAL SPRINGS.
6. SUPERHEATER ELEMENTS AND FLUE TUBES.
7. STEEL BOILER TUBES.

CLASS B.
1. TYRES FOR LOCOMOTIVES.

CLASS C.
1. WIRE GAUZE.

Tenders must be made on forms, copies of which, with specification, can be obtained at these offices on payment as follows:—

For Class A, 30s. each, Class B, 10s. and for Class C, 5s. each (which will not be returned).

The Directors do not bind themselves to accept the lowest or any tender.

S. G. S. YOUNG,
Offices: Secretary.
The White Mansion,
91, Petty France,
Westminster, S.W.1.
29th July, 1921. R 633

THE MERSEY DOCKS AND HARBOUR BOARD

Are prepared to receive

Offers for the Purchase of

ONE PAIR OF DOCK GATES, suitable for entrance about 32 ft. wide by 28 ft. deep, and ONE PAIR for entrance about 45 ft. wide by 32 ft. deep. Built of Greenheart Oak and Baltic timbers.

Arrangements to view can be made on application to the ENGINEER-IN-CHIEF, Dock Office, Liverpool. R 640

THE SOUTH INDIAN RAILWAY COMPANY, LIMITED.

The South Indian Railway Company, Limited, are prepared to receive

Tenders for the Supply of:—

1. Laminated, Volute and Helical Springs.
2. Brushes.
3. Rivets, Nuts and Springs.
4. Copper Plates for Locomotive Fireboxes.

Specifications and Forms of Tender may be obtained at the Company's Offices, 91, Petty France, Westminster, S.W.1.

Tenders addressed to the Chairman and Directors of the South Indian Railway Company, Limited, marked:—"Tenders for Laminated, Helical and Volute Springs," or as the case may be, must be left with the undersigned not later than Two p.m. on Wednesday, the 31st August, 1921.

A charge, which will not be returned, will be made of 20s. for each copy of Specification No. 1, and 10s. for each copy of Specifications Nos. 2, 3 and 4.

Copies of the Drawings may be obtained at the Office of Messrs. R. White & Partners, Consulting Engineers to the Company, 3, Victoria Street, Westminster, S.W.1.

A. MUIRHEAD,
Managing Director.
91, Petty France, S.W.1.
3rd August, 1921. R 677

APPOINTMENTS OPEN.

THE UNIVERSITY OF SHEFFIELD.

FACULTY OF ENGINEERING.

Applications are Invited for

the POST of ASSISTANT LECTURER IN MECHANICAL ENGINEERING.

Salary £400 per annum, including evening work during Winter Session. Candidates holding a University Degree with Honours in Mechanical Science preferred.

Applications, stating particulars of training and experience, accompanied by three testimonials, should be sent not later than August 20th to the undersigned.

W. M. GIBBONS,
Registrar. R 599

LEYTON HIGHER EDUCATION COMMITTEE.

LEYTON TECHNICAL INSTITUTE.

Wanted, a Workshop In-

STRUCTOR at Leyton Technical Institute, Adelaide Road, Leyton, E.10.

Commencing Salary from £250 to £300, according to experience and qualifications.

Experience of modern engineering works in fitting, turning, grinding, &c., essential. Work in a modern tool room, together with some teaching experience an advantage.

Applications to be returned not later than 15th August.

For Form of Application, send stamped addressed envelope to—

R. J. GELDART,
Clerk to the Governors,
Town Hall, Leyton, E.10. R 568

UNIVERSITY OF LONDON, UNIVERSITY COLLEGE.

Applications are Invited for

the position of SENIOR ASSISTANT in the Department of Civil and Mechanical Engineering, which is under the direction of Professor E. G. Coker. The work requires training and experience in Engineering Design and Drawing Office practice.

Salary £450 to £500 (pensionable) according to qualifications and experience. Further particulars may be obtained from:

WALTER W. SETON, M.A., D.Litt.,
Secretary,
University College, London,
Gower Street, W.C.1. R 639

LONDON COUNTY COUNCIL.

Applications are invited for

the APPOINTMENT of ASSISTANT DIVISIONAL OFFICER in the London Fire Brigade. Candidates must be of robust health, strong and active, and their ages must not be less than 25 and not more than 30 years. They must have had a good general education and must possess a sound knowledge of mechanical engineering. Experience in the control of men is essential.

The salary is £400 a year rising by annual increments of £25 to £500 (based on pre-war conditions), with free quarters, uniform, coal, light and medical attendance, such allowances being valued for the purpose of pension at £75 a year. The salary is subject to fluctuating temporary additions, making the commencing remuneration at present £747 12s. 3d. a year. The temporary additions are due for adjustment on 1st September, 1921, when a reduction will occur.

Preference will be given to candidates who have served or attempted to serve with H.M. Forces. Candidates who have not so served must be natural born British subjects.

Particulars and forms of application may be obtained from the Clerk of the Council, County Hall, Spring Gardens, S.W.1, and must be returned to him not later than Eleven a.m. on Monday, 12th September, 1921, endorsed "Assistant Divisional Officer, L.F.B." An addressed *foolscap* envelope bearing 2d. stamp must be sent with the request for form of application. Canvassing disqualifies.

JAMES BIRD,
Clerk of the London County Council.
R 653

Research Department,
ROYAL ARSENAL, WOOLWICH.

DIRECTORATE OF METALLURGICAL RESEARCH JUNIOR ASSISTANT.

Required, One Metal-

LURGIST; should be graduate who has received a University training in Metallurgy.

Initial salary £160 and bonus. (Total emoluments at present £392 19s. 6d.).

Annual leave, 24 days.

Applications in writing, accompanied by copies of not more than three testimonials should be made to the CHIEF SUPERINTENDENT, Research Department, Royal Arsenal, Woolwich, S.E.18, from whom the conditions of Employment may be obtained. R 516

ROYAL AIR FORCE CIVILIAN EDUCATIONAL STAFF.

Applications are Invited

for the appointment of HEAD-MASTER of the Boy Mechanics School at the No. 2 School of Technical Training (Boys) at Cranwell, Lincolnshire. The number of boys under training in this establishment will be about 1350, all of whom attend the school for 8 hours a week for a course of general and technical education. There is a staff of 19 senior and assistant masters.

The scale of salary will be £450—£30—£550 plus Civil Service Bonus (estimated at approximately £286 on first appointment).

Further particulars together with a form of application may be obtained from the SECRETARY (A.E.), Air Ministry, Kingsway, London, W.C.2. R 644

London Representative

WANTED by a firm of Constructional Engineers in the North to secure orders for Pit Tubs, Light Railway Stock and Constructional Steelwork. To a suitable man the prospects are very good and a high salary and bonus will be paid. Reply should state in confidence age, experience, references and suggested remuneration.—BOX 286, Willings, 125, Strand, W.C.2. R 626

Engineer.—Wanted, by

Colliery Company, a Qualified ENGINEER to superintend plant and workshops. Experience with wagon repairs necessary. Salary £500-£600.—Address, stating age, experience, etc., ENGINEER, Wm. Porteous & Co., Advertising Agents, Glasgow. R 618

Heating and Ventilating En-

GINEER REQUIRED by London Firm. Previous technical and commercial experience essential and knowledge of the Plenum System desirable. Reply, giving particulars of experience, age and salary required.—Address, R 622, Offices of Engineering.

Heating and Ventilating.—

Competent ENGINEER REQUIRED by London firm. Must be capable of supervising contracts. Practical experience of Heating work essential.—State fully qualifications, and experience, age and salary required.—R 606, Offices of Engineering.

Engineer (Practical) Wanted

to TAKE entire CHARGE of Boilers, Economisers, Quickspeed Engines and Turbo Set, A.C. and D.C. Generators and Motors, Shafting, Gearing, etc., in a large tensile works. Should be a fair draughtsman and able to lay off Buildings and Heavy Foundations. Ex-service man preferred.

Apply stating age, experience, and salary expected.—Address, R 657, Offices of Engineering.

Wanted, Works Manager

for Engineering Works employing about 200 hands. Must be good practical man, with sound technical training and organising ability, used to the control of men.—Apply, stating age, salary required and full details of training and experience.—Address, R 635, Offices of Engineering.

Chief of Estimating Depart-

MENT REQUIRED for Locomotive Works. Excellent position and prospects for the right man. Applications in strict confidence.—Address, R 676, Offices of Engineering.

Draughtsmen Wanted, ac-

customed to Coal Washing, Screening, and Conveying Plant.—Apply giving full particulars of experience, and stating age and salary required, to THE GRANGE IRON COMPANY, Limited, Durham. R 651

Heating and Ventilating.—

DRAUGHTSMAN REQUIRED by London firm, must be experienced and capable of preparing schemes and estimates. State age and qualifications, and salary required.—Address, R 607, Offices of Engineering.

Required, for Large Firm of

Constructing Engineers in Spain, several experienced locomotive DRAUGHTSMEN, single men preferred. State age, previous engagements, with length of service, and details of work carried out, giving copies of references and salary required. Knowledge of Spanish or French desirable.—BOX S. 770, care of Dawson's Advertising Agency, 121, Cannon Street, E.C.4. R 667

Wanted by a London Firm,

a Heating and Ventilating DRAUGHTSMAN. State age, experience and salary required to BOX No. H. 1519, care of Dawson's, 121, Cannon Street, E.C.4. R 668

Wanted, a Highly

Experienced MAN with a thorough knowledge of the costs of maintenance in an Engineering Works of large size. State age, experience, and salary required.—Address, R 613, Offices of Engineering.

Wanted immediately Fore-

MAN used to Aerial Rope Traction for appointment abroad.—Address, R 660, Offices of Engineering.

THE 72-IN. REFLECTING TELESCOPE FOR THE DOMINION OF CANADA.

THE installation near Victoria, British Columbia, by the Canadian Government, of the 72-in. reflecting telescope, the erection of its dome and housing, and all its accessories, marks the completion of one of the largest and most complete astrophysical observatories in the world. It is an out growth of the work of the Dominion Astronomical Observatory at Ottawa, Canada. The Dominion of Canada granted the money for this project and placed the contracts in October, 1913, with the Warner and Swasey Company of Cleveland, Ohio, for the mounting and with the J. A. Brashear Company, of Allegheny, for the optical parts of the instrument. The designing of the great telescope, dome and accessories occupied a period of about one year before actual production was started in the works. Another year and a half was spent in the fabrication of the telescope and dome so that in May, 1916, the telescope was assembled at the works of the Warner and Swasey Company and all movements and controls thoroughly tested. In the meanwhile the site for the observatory had been purchased and the grounds prepared. The observatory was finally located at Observatory Hill, an elevation of about 730 ft. situated 8 miles north of Victoria, British Columbia. The observatory, of which an external view is given in Fig. 1, on Plate IX, was erected with a massive concrete pier to which we shall refer later.

The dome was constructed, erected, and tested at the works of the makers simultaneously with the telescope. Shortly after the telescope was accepted the dome was shipped to Victoria and erected. The telescope was then dismounted, packed and shipped to Observatory-hill at Victoria, British Columbia, and subsequent erection occupied a further six months; so that in October, 1916, the mechanical parts of the telescope were finally erected at the observatory, exactly three years after the contract was let—a remarkably short time for an undertaking of this character.

The optical parts of the instrument, however, were delayed because of the urgency of war work, on which Messrs. Brashear were engaged, and because of the impossibility of securing at that time the large glass discs required for the testing of the mirror. It was thus not until early in May, 1918, that the mirror was completed, shipped to Victoria and installed in the telescope.

The observatory itself, as will be seen from Figs. 1 and 3, Plate IX, is a cylindrical building 66 ft. in diameter, of structural steel, covered inside and outside with sheet steel. The walls are cylindrical with a conical skirting at the base and are hollow to provide for free circulation of air thus permitting of the maintenance in the building of a more nearly uniform temperature. The building is of two-storey design with the lower floor devoted to dark rooms, laboratories and office facilities. The upper floor of the observatory is formed of $\frac{7}{16}$-in. checkered steel plates and is 21 ft. 6 in. above the lower floor. The entrance is at the south side of the building which is adequately provided with windows. The circular wall terminates at its upper end 10 ft. 9 in. above the upper floor, in a heavy plate and channel construction (see Fig. 3) upon which two heavy 12-in. circular I beams are fixed. These I beams form the foundation for the dome and its track.

The dome itself is polyhedral in form with a conical skirting. The skirting extends well down over the track and trucks, making the whole construction weatherproof. On one side of the dome and extending radially well past the centre is the large rectangular opening through which observing is carried on. This opening is closed when the telescope is not in use by double shutters which slide across one from either side. The shutters give a free aperture of about 17 ft. when fully opened. The dome, of which a view taken during erection, is given in Fig. 2, has a diameter of 66 ft. and is of structural steel construction, covered inside and outside with Toncan sheet steel. This form of construction permits the air to circulate freely up through the building walls, thence through the dome walls and out through the louvres at the top of the shutter, and thus aids materially in securing a uniform temperature throughout the building.

The dome rotates about the centre of motion of the telescope, and to do this it rolls upon a circular track on the top of the wall of the building, This track consists of an 80 lb. T rail correctly bent. the sections having milled and dowel-pinned ends where they join and being planned to a true curve on the top and sides. The track rests upon 32 single track blocks and 16 double track blocks. These adjusting blocks are bolted to plating over the 12 in. I beams on the building wall.

The bottom of the dome has a circular girder construction made up of heavy channels, angles, and steel plate. Its system of bracing makes it very stiff and rigid. The dome rests upon twenty-four trucks; these trucks are of extra heavy construction with wheels 30 in. in diameter. Their axle bearings are of the roller type with ball-thrust spherical self-aligning seats. Twelve lateral guiding trucks with two heavy wheels each side take charge of side strains.

The structural part of the dome consists of two pairs of heavy main ribs bridging the dome, and twenty-two long and twenty short radial ribs all fastened to the lower circular base section. These ribs are spaced and held in position by three sets of chordal members, equally spaced, starting from the bottom circular section. The two bridging main ribs are very heavy and strong, as they were intended to afford support in hoisting and placing the heavy telescope parts in position. These main ribs are of plate and angle iron construction with small angle lacings. Just a short distance outside of each of these main ribs and parallel to them are two auxiliary ribs. The larger ribs are 42 in. while the smaller pair are only 15 in. deep. These two pairs of main ribs carry several sets of tracks, supporting the observing platform, shutter and wind curtain. These main ribs also carry extensions, reaching nearly to the floor, for the ladders and counterweight tracks as well as for the shutter and curtain operating mechanisms to which we shall refer later.

The lighter radial ribs are built up of channels laced to form latticed girders and are all bent to the radius of the dome. These hold the circular angles to which the sheathing is attached, and also support and stiffen the main ribs. At the top of the dome, also at the lower end of the shutter opening are two heavy parallel tracks of 80 lb. T rails tangent to the dome, upon which the shutters roll to open and shut. To the lower end of the radial ribs are attached the bent angles which form the support for the conical skirting, already referred to, which covers the track and trucks.

As already stated, the shutter is made in two parts which roll outward from the centre to uncover the opening for observing. Each part is a rectangular frame of plate and angles bent to the radius of the dome. The end sections are of plate and channel construction held together by channel and lattice spacers. At the upper and lower end of each part are heavy transverse members of channel plate and angle iron, to which are fastened the trucks and lateral guide wheels which support the shutters. Each shutter with its trucks and lateral guide wheels rolls upon the I beam fastened to the outside of the dome. The shutters are covered outside and inside with Toncan sheet metal covering and have louvres at their upper ends to allow air to pass.

An endless steel cable operates the shutters, passing over sheaves on the side of the main ribs to a motor driven winding drum. This cable is fastened securely to both the upper and lower end of each shutter, and is motor operated pulling simultaneously at the top and bottom of each shutter, and giving the shutters a parallel motion in opening and closing. This operating mechanism consists of a 2 h.p. reversing motor driving a drum through a worm and worm wheel, the drum being connected to the motor by a hand operated clutch. This mechanism is located upon a platform at the lower end of the shutters and is reached by an iron stairway attached to this platform and extending to the floor below. This platform also carries the mechanism for operating the wind curtain and the observing or elevating platform described later.

A wind curtain is provided to reduce the size of the shutter opening while observations are in progress. It operates horizontally across the shutter opening. The heavy canvas curtain is in two parts each being supported on a series of rods carrying rollers at either end. The rods are spaced by short chains which relieve all tension on the canvas in adjusting the curtains. Cables connect the curtains to worm-driven drums, described above, which in turn are connected to the shutter motor by hand clutches. Thus each half of the curtain can be operated independently, enabling the observer to obtain any size of opening whenever desired.

In a reflector, arranged for observing at the prime focus, or the Newtonian focus, the observer is required to work at the upper end of the tube, and as this may be at considerable height from the floor in an instrument of this size, it was necessary to design some form of observing platform, easily controlled to permit free and easy access to the upper end of the tube in all positions of the telescope. For this purpose an observing bridge is provided, allowing the observing position to be readily reached at all points from near the horizon to the zenith.

Attached to the sides of the main ribs along their entire length are four heavy T rails, bent to the radius of the main ribs for the purpose of supporting two trucks, carrying the observing bridge. These trucks run on the main ribs on the side of the shutter opening, while on the side opposite heavy counter weights are supported. Attached to the lower end of each of the bridge supporting trucks is a swivel bracket from which the bridge is hung. The bridge or platform proper consists of two latticed steel supporting frames to which the elevating platform is rigidly bolted. The bridge is 20 ft. long and 4 ft. wide with two wings on its inner side which can be moved longitudinally. These wings are supported upon tracks and retaining wheels which are guided by T rails and channels on the lower side of the platform. The wings project 6 ft. from the bridge. When the end of the telescope tube is at the middle of the bridge, the wings are brought up on either side, giving the observer ready access to any point at the end of the tube. The bridge wings are adequately provided with railings to make them perfectly safe. The observing bridge is well shown in Fig. 3 on Plate IX.

As the carrying truck is nearly vertical when the bridge is at its lowest position, and nearly horizontal at its upper limit, due to its running on a circular track, it was necessary to devise some method for keeping the platform level at all times. This is accomplished by a swivel bracket, connecting the truck to the platform at its rear end, and by allowing the bridge to hang from the truck at its forward end by equalising cables, and an equaliser counterweight cable. As already stated, the operating mechanism for the elevating platform is on the platform at the bottom of the shutter; it consists of a 5 h.p. back-geared reversing motor, driving by gear and worm reduction a pair of different sized drums mounted upon the same shaft. To the smaller drum is attached an endless cable which runs up over sheaves to a set of adjusting sheaves on the top of the dome, down to the truck, and thence on down around the drum again. The winding or unwinding of this cable moves the trucks up or down the main ribs thus moving the bridge. Attach to the larger drum is another cable which runs up over sheaves to the sheaves on the top, down to the truck and over the sheave thereon and is fastened to the front edge of the bridge support. As the drum is rotated these two cables are wound up at different rates, the slower cable is pulling the truck and platform up, while the other cable, being wound more rapidly, is pulling on the inner end of the bridge, thus correcting the turning tendency due to the change of level of the truck on the curved track.

The truck and bridge weigh about 5½ tons, and require suitable counter balancing to produce a smooth even motion. Upon the track, at the side of the dome main ribs opposite the bridge are four large steel cylindrical counter-weights mounted on trucks fastened to cables which are in turn fastened to the elevator truck. Moving between these counter weights are two others fastened to cables which run over sheaves on the truck; they are also attached to the bridge midway between the equaliser cable and the swivel bracket. These are called the equaliser counter weights, their function being to

counteract the weight of the inner end of the platform as it is swivelled about the truck attaching point, and thus keep the platform level. An adjustable feature is provided in the sheaves at the top of the dome to compensate for uneven stretch in the elevator cables and equaliser cables; this permits the levelling of the platform transversely. The platform with its counter weights and a load of as many as eight persons moves very smoothly and evenly. It is controlled by a variable speed controller on the bridge, allowing it to be moved at a rate of from 1½ ft. to 6 ft. per minute. At its lowest position the bridge stops on a level with the platform at the bottom of the shutter.

Leading from this last-mentioned platform and ascending alongside the observing or elevating platform is a movable stairway reaching to the top of the dome. The stairway is so built that the elevating platform can be easily reached at any position. This stairway is pivotted at its centre, and the upper end attached to a chain and counter weight enabling it to be swung out of the way in moving the telescope.

The entire dome rotates upon its track to permit the shutter opening to be pointed to all parts of the heavens. This is accomplished by an endless cable running around the lower part of the dome cable track and down over a motor-driven drum. The circular cable track is of angle-iron attached to bottom of the dome by bent angles. At the west side of the dome is a pair of sheaves which lead the cable down to the motor-driven drum and up over a tightening cable. All slack in the cable is taken away by a 1½ ton weight suspended from the tightening sheave. With the endless cable arrangement it is possible to continuously rotate the dome in either direction. The winding drum, driven through gear and worm reduction by a 7½-h.p. reversing motor, and the tightening sheaves and counter weight, are located on the lower floor of the observatory building. The moving weight of the dome, elevating carriage and shutters, is approximately 530 tons; its speed of rotation is one revolution in six minutes.

The dome and its accessories are electrically operated throughout. The dome-turning mechanism is operated by a reversing controller located at either side of the south pier. The shutter mechanism is operated by a reversing controller and by a hand clutch located on the platform. The wind curtain is also operated by the same controller switch and a pair of hand clutches situated on the platform as described above. The method of operation then is as follows:—First, the telescope is set to the tabular position by means of the quick motions, after which the driving clock is started; Second, the dome is revolved until the shutter is over the end of the tube, these operations being carried out from the south pier head. The observer then mounts to the shutter platform, opens the shutters, and adjusts the wind curtains; from there he proceeds to the bridge and elevates it to the observing position.

A massive pier of reinforced concrete supports the telescope. The pier, the form of which is clearly shown in Fig. 3, Plate IX, has two columns which rise at its north and south ends. The north pier rises to a height of 21ft. 6in. above the upper floor, and is 5 ft. square at the top. The south pier rises 4 ft. above the upper floor, with a top 9 ft. by 5ft. These piers serve to hold the cast-iron pillar blocks and pier heads upon which the telescope rests. Directly north of the south pier head, and extending into it, is the base plate for the driving clock. A well for the clock weights and winding cable extends down through the arch, as seen in Fig. 3. The pier rests directly on the granite bed rock of the mountain top. The weight of the pier with its structural work is about 600 tons.

The telescope consists of an optical system and a mounting suitable to hold it in alignment and enable it to be directed to any desired portion of the heavens. The optical system of a reflecting telescope consists of an image-forming part and the viewing part or eye-piece, which serves to magnify the image formed by the mirror. In addition to these there may be various secondary parts, such as amplifying lenses and mirrors, and prisms and mirrors for bringing the observing point to a convenient position and for increasing the magnification. The optical system of the 72-in. Reflector consists of the main speculum or mirror of 72-in. clear aperture, and 30 ft. focal length, combined with either a Newtonian flat, or with a Cassegrain mirror. It may also be used in the prime focus without either of these secondary mirrors.

The mounting, which comprises the whole mechanism, consists of the tube which is supported by a pair of co-ordinate axes about which the tube may be moved, and a driving clock. The great tube of the Canadian Reflector supports at its lower end the the large mirror behind which is attached the spectrograph, while at its upper end provision is made for a photographic plate holder, in the prime focus, and the removable attachments for the secondary mirrors. The co-ordinate axes enable the tube to be pointed, as we have stated, at any desired portion of the heavens. The main or polar axis is parallel to the axis of the earth so that rotation about this axis will exactly follow the apparent motion of the stars, due to the earth's rotation. From this fact, the name "equatorial mounting" derives its origin. The secondary axis, called the declination axis, exactly at right angles to the polar axis, is provided to enable the tube to be moved in declination.

The tube is attached to the end of the declination axis. The driving clock, connected to the polar axis by gearing, provides the necessary means for moving the telescope tube in following the star. The whole general arrangement is well shown in Fig. 3, Plate IX, while general photographic views of the telescope in two positions are shown in Figs. 8 and 9, on page 222.

The polar axis is made in three pieces: the upper and the lower conical sections and the cubical centre-piece. These are all steel castings and are thoroughly annealed. In the machining process the upper and lower sleeves were provided with forged steel pivots which were pressed in, and the assembled axis was turned up on all bearings at one setting, assuring a true concentricity of alignment. The polar axis is about 21 ft. long and weighs 18,900 lbs. It rests on ball bearings of the self-aligning type. The upper bearing, which is illustrated in Figs. 4 and 5, annexed, is 8·740 in. bore, 18·26 in. outside diameter, and 5¼ in. wide, it has 3 in. diameter balls. The lower bearing, which is illustrated in Fig. 6, above, is in two parts, *i.e.*, the radial and the thrust bearing. The radial bearing is 9·025 in. bore, 19·31 in. outside diameter, and 5¼ in. thick, and has 3½ in. balls in two rows. The thrust bearing is of the ball thrust type mounted in a forged steel ring which rests on a rocker. This rocker has a cylindrical surface on its top and bottom face; the axis of the cylinders being 90 deg. from each other.

In erecting the instrument for preliminary tests

Fig. 4.

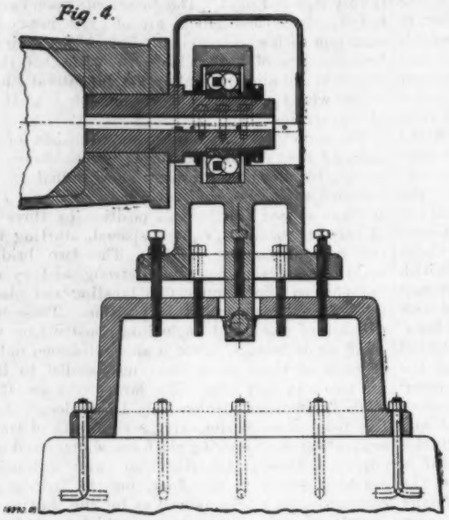
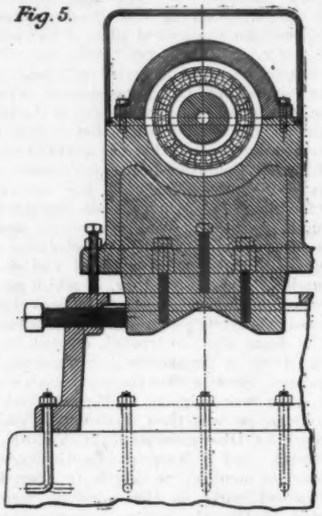


Fig. 5.



Figs. 4 and 5. Upper Bearing of Polar Axis and Section of North Pier Head.

Fig. 6.

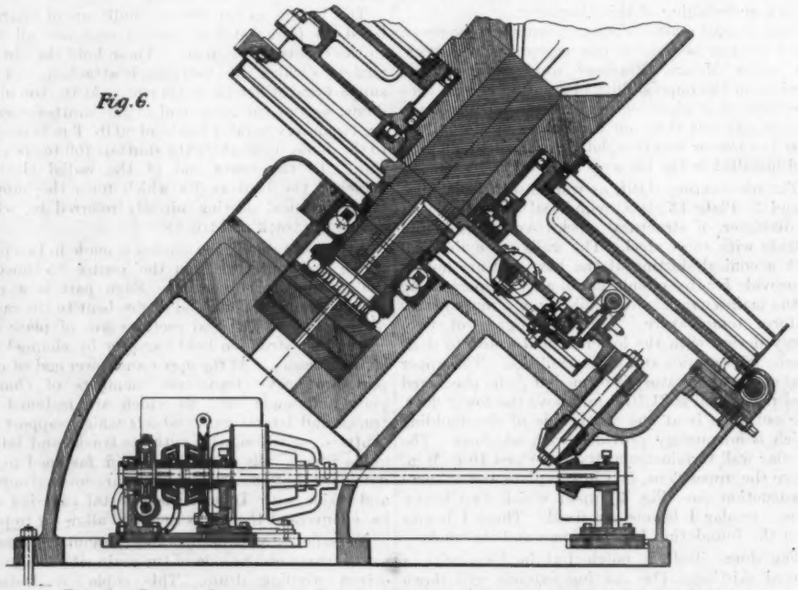


Fig. 6. Lower Bearing of Polar Axis and Section of South Pier Head.

the polar axis was mounted horizontally on its bearings and balanced and the co-efficient of friction was then roughly determined. At a radius of 30 in. it required the addition of a 4 lb. weight to start the axis rotating after which 3 lbs. sufficed to keep it in rotation. This gives the following results :—

Starting co-efficient	0·00020
Running co-efficient	0·00015

It should be borne in mind that these bearings carry a constant load of 10 tons.

The declination axis is a gun-steel forging 15½ in. diameter, 14 ft. ½ in. long, with a flange at one end 41 in. in diameter and 4 in. thick, to which the centrepiece of the tube is attached. This axis weighs 9,225 lb. It is mounted in ball bearings, like the polar axis. The declination axis goes through the cubical section of the polar axis at exactly right angles, and the upper bearing cell of the declination axis is in this cubical centrepiece. This upper bearing consists of a radial and a thrust bearing. The radial bearing is 16 in. bore, and

Fig. 7.

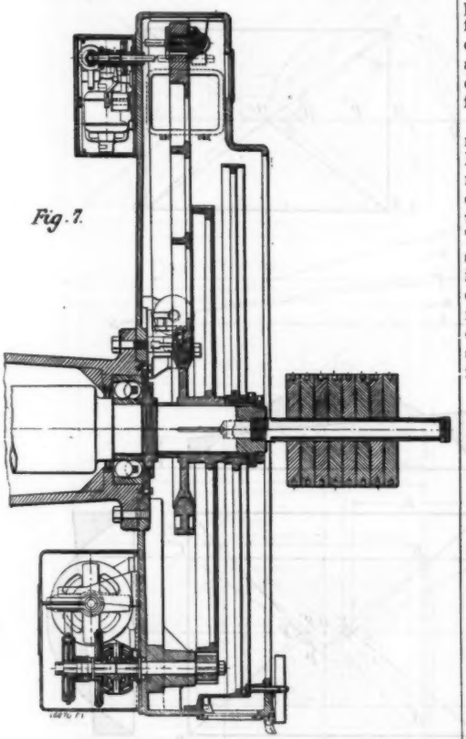


FIG. 7. OUTER END OF DECLINATION AXIS WITH SECTION OF DECLINATION CIRCLE AND OPERATING MECHANISM.

21 in. outside diameter, and 3 in. thick. The balls are 1½ in. diameter. The double thrust bearing consists of a double ball bearing resting in spherical seats, and is 15⅞ in. bore, 20¾ in. outside diameter and 5½ in. thick. The lower bearing of the declination axis is in the outer end of the declination sleeve, as shown in Fig. 7. This sleeve is bolted to the centrepiece of the polar axis. This bearing is 9·025in. bore, 19·31 in. outside diameter, and 5 in. thick, and has 3⅛ in. diameter balls.

All ball bearings are enclosed in dust-proof housings, filled with light grease, and will require lubrication at intervals of several years only. This is the first telescope ever built in which the bearings for alignment are also used as anti-friction bearings ; it marks a great step forward in the design of instruments in that accuracy of alignment, and a most sensitive and smooth motion are combined in one bearing. This construction affords an exceptionally sensitive instrument, and gives a very smooth and even-working slow motion speed, whereas in the older type of instruments there was always a tendency to surge in very fine setting speeds. All previous types of instruments used plain cylindrical bearings for alignment, and rollers or mercury floats to relieve the friction.

The polar axis rests on two pier heads (well shown in Fig. 3 on Plate IX), which carry the bearings already described. The lower or south pier head is a hollow cast-iron pier of seven tons weight. It contains the radial and thrust bearing seats, and also houses the quick motion gearing in right ascension. The upper or north pier head is divided into two parts, namely, the north pillar block, which is fixed to the concrete pier, and the north bearing head, which is movable. The two parts are of cast iron, and together weigh 5½ tons. The north bearing head contains the upper bearing of the polar axis, and can be moved up or down by jack screws, giving the correct angle of elevation for the polar axis. The pier head can also be moved sidewise, *i.e.*, in an east and west direction so as to place the axis in the exact north and south meridian. Such movement is, of course, necessary only in making the initial adjustment of the telescope. The declination sleeve is attached to the cubical centrepiece of the polar axis, and at the side opposite the flange of the declination axis. This is in general outline the same as the upper part of the polar axis, and serves as a support for the bearing at the outer end of the declination axis, as well as for the housing for the declination gearing.

The declination housing (see Fig. 7) is a heavy ribbed casting, 8 ft. 6 in. in diameter and 2 ft. deep. It is cylindrical in shape, and has a large hollow rectangular extension at one end ; to this the declination slow motions are attached, and into it the end of the declination slow motion arm extends. The bottom is closed by two semicircular sheet steel plates, with hand holes for reaching the interior of the declination housing. To the inside of this housing are attached the slow motion clamp mechanism and slow motion arm and declination circle multiplying drum, and to the top and on the side opposite the extension at the other end is fastened the declination quick motion gearing.

(To be continued.)

A METHOD OF CALCULATING THE STRENGTH OF SLABS.

By A. INGERSLEV.

THE calculation of the stresses occurring in slabs supported along the circumference, is becoming of constantly increasing importance. In reinforced concrete construction the mesh-reinforced slab is being used very frequently, and in shipbuilding the problem of calculating the strength of bulkheads has not yet found a satisfactory answer. Any exact solution based on the mathematical theory of elasticity is too cumbersome to be adopted in practice, and the empirical formulas commonly used have not in many cases even been verified by actual test. It is however possible, with one assumption granted, to devise formulas for the strength which shall be applicable to any type of loading and to different shapes of slab.

The assumption required will be most easily understood by referring to the rectangular slab represented in Fig. 1 by A B C D.

Experiment shows that such a slab breaks under a uniformly distributed load along the lines indicated by E F, E A, E B, F C and F D. We will term the figure composed of these lines the breach, and we can say at once : That (1) the bending moment (B.M.) is a maximum along the breach, therefore (2) there is no shear along the breach, and we shall also make the assumption that (3) the B.M. per foot run is the same at all points of this breach.

This assumption cannot be far wrong once the stresses on the steel has passed the yield-point, and it is supported by the fact that in actual tests the cracks start at the same time along E F and along the other lines of the breach.

With this assumption we can solve our problem because, were we now to cut up the rectangle along the lines of the breach, each of the figures A E B, B E F C, C F D and D F E A would remain in equilibrium under their load if we added the B.Ms. acting along the breach.

Take the case of the triangle A E B. If in equilibrium, the moment round any axis (for instance A B) should be equal to zero. The resultant bending moment along A B is that due to the load carried plus the resultant of the B.Ms. acting along A E and E B, the nature of which is represented in Fig. 2.

A bending moment can be represented by a vector just as a force can be, and the resultant of two bending moments can accordingly be determined in the same way as that of two forces. In Fig. 3, page 310, P and P represent a couple with a lever arm a. This couple acts in the plane A, and V′ V represents a normal to this plane. The moment round an axis M′ M forming an angle α with V′ V is $M = P\,a \cos \alpha$. If, therefore, we were to represent the moment $P\,a$ by a vector along V V′, the moment round any other axis such as M′ M is represented by the projection of the vector ($P\,a$) on this axis M′ M.

The same applies to any other couple, so the total moment round any axis M′ M due to any number of moments is given by the relation :

$$M = \Sigma\,(P\,a) \cos \alpha$$

which corresponds exactly to the resultant of a number of forces acting at a point.

The direction of the vector representing a moment we shall take as positive when, on holding the right hand over the couple, the thumb points in the direction of rotation indicated by the couple. The arrow denoting the direction of the vector is then drawn pointing towards the palm of the hand (see Fig. 3, page 310).

Fig. 1.

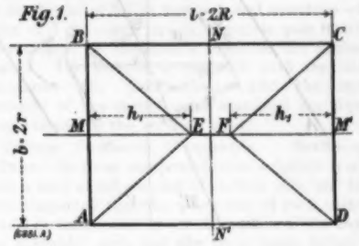
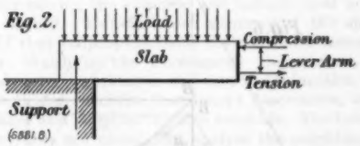


Fig. 2.



We now return to the problem before us. If, according to our assumption, the B.M. per foot run is the same at all points of the breach, then the B.Ms. along the breach may be represented by vectors, the lengths of which are the same as the lengths of the corresponding lines of the breach.

For the B.Ms. along A E and E B therefore the resultant of A E B is A B and the sum of the B.Ms. along D F E A = D A.

The moment round A B due to the load is $M_b = \frac{1}{2}\,p\,h_1^2 \times b$, and the moment of the load on the trapezoid D F E A : (D A = $l = 2R$; A B = $b = 2r$; M E = F M′ = h_1), is $M_l = p\,[\frac{1}{2}\,r^2\,(2R - 2h_1) + \frac{1}{3}\,h_1\,r^2] = pr^2\,(R - \frac{2}{3}\,h_1)$.

Then on the assumption from which we started, viz., that the bending moment along the breach is uniform, we must have :

$$\frac{M_b}{b} = \frac{M_l}{l} \text{ or } \frac{S_b}{b} = \frac{S_l}{l}$$

where S_b and S_l are the static moments of the figures A E B and D F E A round the corresponding sides A B and D A.

Hence :

$$\frac{\frac{1}{2}\,h_1^2\,b}{b} = \frac{r^2\,(R - \frac{2}{3}\,h_1)}{2R} \quad . \quad . \quad . \quad (1)$$

or

$$h_1^2 + 2\,\frac{r^2}{R}\,h_1 - 3\,r^2 = 0 \quad . \quad . \quad . \quad (2)$$

$$h_1 = r\left[\sqrt{3 + \left(\frac{r}{R}\right)^2} - \frac{r}{R}\right] \quad . \quad . \quad (3)$$

from which m the bending moment per foot run is given by

$$m = \frac{1}{2}\,p\,h_1^2 \quad . \quad . \quad . \quad . \quad . \quad (4)$$

It is obvious that this formula is right for a square. In that case, we have:

$$\frac{r}{R} = 1; \quad h_1 = r; \quad m_0 = \tfrac{1}{8} p r^2 = \tfrac{1}{32} p a^2 \; (2r = a)$$

It is also correct in the case of a very long narrow slab, since then $\frac{r}{R}$ becomes so small as to be negligible, so that:

$$h_1 = r\sqrt{3}. \quad m_0 = \frac{p r^2}{2} = \tfrac{1}{8} p a^2.$$

We note that the direction of the lines radiating from E and F changes from that corresponding to $\frac{h_1}{r} = 1$; in which case $\alpha = 45$ deg. when the slab is square to $\frac{h_1}{r} = \sqrt{3}$; giving $\alpha = 60$ deg. in the case of a very long narrow slab.

Fig. 3.

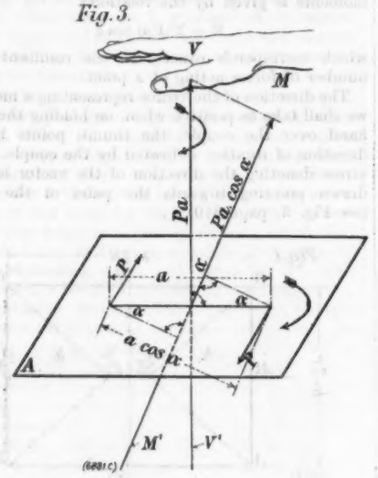


Fig. 5.

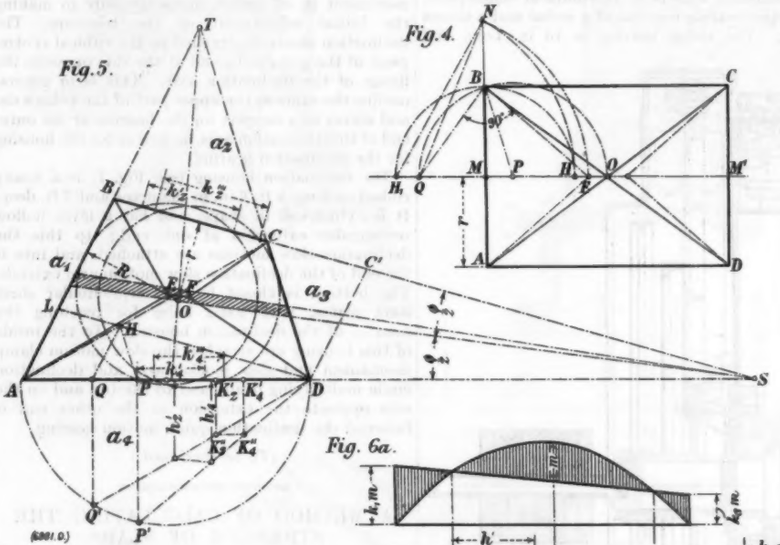


Fig. 4.

Fig. 6.

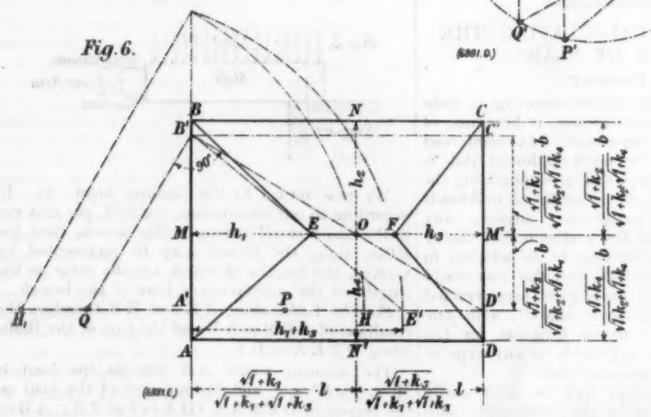
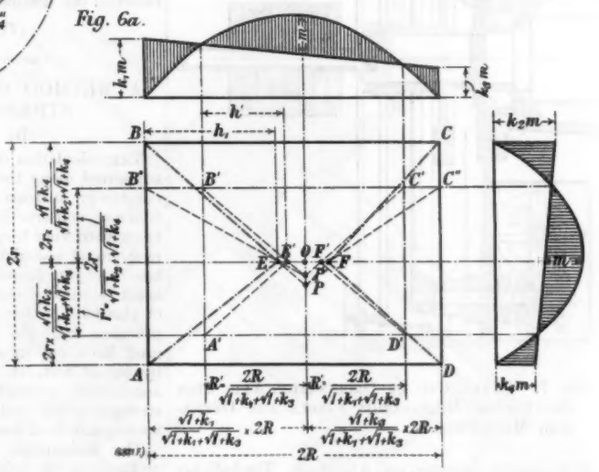


Fig. 6a.



This deduction can be compared with experiment, and thus provides a test of the trustworthiness of the hypothesis from which we started.

The photographs reproduced in Fig. 7 permit of this comparison being made. A graphic method of determining the value of h_1 is represented in Fig. 4.

Here Q B is perpendicular to B D, and therefore

$$Q M = \frac{r^2}{R}.$$

whilst

$$M H = M H_1 = M B = r.$$

If we draw the circle H N having centre at H_1, and radius H H_1, then

$$M N = r\sqrt{3}$$

and

$$Q N = \sqrt{3r^2 + \frac{r^4}{R^2}}.$$

If we now draw the circle N E having its centre at Q and radius Q N, then M E $= h_1$.

If the slab is not rectangular but any four-sided figure we may still apply the formula, only in this case r and R denote distances from the "centre" O. of the slab to opposite pairs of sides. The centre O lies at the point of intersection between the two lines halving the angles between the pairs of sides.

Consider, for example, the four-sided figure A B C D represented in Fig. 5. Let A B $= a_1$; B C $= a_2$; C D $= a_3$; D A $= a_4$. Then a_2 and a_4 have a point of intersection at S and form an angle ϕ with one another, whilst a_1 and a_3 intersect at T and include an angle θ. The bisectors of these angles determine O. The distances from O to a_1 and a_3 are each equal to R, and the distance to a_4 and a_2 are both equal to r. In the case of these irregular slabs we assume that the line E F of the breach passes through S, and further that the two figures formed by the breach are triangles on the two sides a_1 and a_2 that are furthest removed from O.

The static moments of the figures formed by the breach each round the corresponding side (a_1, a_2, &c.) are represented by S_1, S_2, &c., and must satisfy the equations:

$$\frac{S_1}{a_1} = \frac{S_2}{a_2} = \frac{S_3}{a_3} = \frac{S_4}{a_4},$$

but

$$\frac{S_1}{a_1} = \tfrac{1}{8} h_1^2$$

and

$$\frac{S_3}{a_3} = \tfrac{1}{8} h_3^2,$$

therefore $h_1 = h_3$.

It will be seen that the line E F of the breach differs very little from the line halving the angle ϕ, and will pass on the same side of O where point T is to be found. From what we have said already, we should be able to see how far we were right in giving the formulas (3) and (4) a general application. As a result of this investigation we may say:

Provided the projections of O on the four sides fall on the sides themselves, and not on the sides produced, the bending moment in any four-sided slab may be determined by the relation:

$$\tfrac{1}{8} p h_1^2 \quad . \quad . \quad . \quad . \quad . \quad . \quad (3)$$

and

$$h_1 = r\left[\sqrt{3 + \left(\frac{r}{R}\right)^2} - \frac{r}{R}\right] \quad . \quad . \quad (4)$$

So far we have only considered the slab freely supported along its periphery.

If the slab is fixed along the edges, our original assumption no longer suffices, because we do not know what portion of the moment $p \times S_a$ is balanced by the moment at the support and what portion by that along the breach.

An approximation can, however, be made by assuming what fraction of the resulting B M in the centre is taken along the edges. Consider a rectangular slab fixed along the sides. Let the bending moment along the breach be m and the bending moment per foot run along the edges a_1, a_2, a_3 and a_4 be given by the relations

$$m_1 = k_1 m; \; m_2 = k_2 m; \; m_3 = k_3 m \text{ and } m_4 = k_4 m.$$

It then follows (see Fig. 6) that:

$$m = \tfrac{1}{8} p h_1^2 - k_1 m = \frac{R - \frac{h_1 + h_3}{3}}{2R} p h_2^2 - k_2 m$$

$$= \tfrac{1}{8} p h_3^2 - k_3 m = \frac{R - \frac{h_1 + h_3}{3}}{2R} . p h_4^2 - k_4 m$$

or

$$m = \tfrac{1}{8} p \frac{h_1^2}{1 + k_1} = \frac{R - \frac{1}{8}(h_1 + h_3)}{2R} p \frac{h_2^2}{1 + k_2}$$

$$= \tfrac{1}{8} p \frac{h_3^2}{1 + k_3} = \frac{R - \frac{1}{8}(h_1 + h_3)}{2R} . p \frac{h_4^2}{1 + k_4} \quad . \quad (5)$$

Now let

$$h' = \frac{h_1}{\sqrt{1 + k_1}} = \frac{h_3}{\sqrt{1 + k_3}} \quad . \quad . \quad . \quad (6a)$$

and

$$r' = \frac{h_2}{\sqrt{1+k_2}} = \frac{h_4}{\sqrt{1+k_4}} = \frac{2r}{\sqrt{1+k_2}+\sqrt{1+k_4}} \quad (6B)$$

and

$$R' = \frac{2R}{\sqrt{1+k_1}+\sqrt{1+k_3}} \quad . \quad . \quad (6C)$$

Substituting in (5) we get:

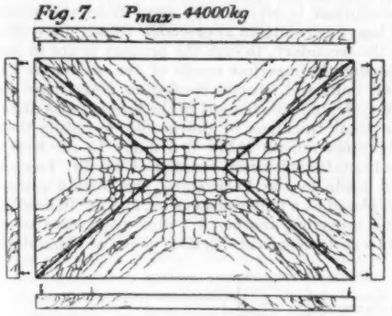
$$m = \tfrac{1}{6}\, p\, h'^2 = \frac{R' - \frac{2}{3}h'}{2R'} \quad p\, r'^2 \quad . \quad . \quad (7)$$

On comparing (7) with (1) we see that:

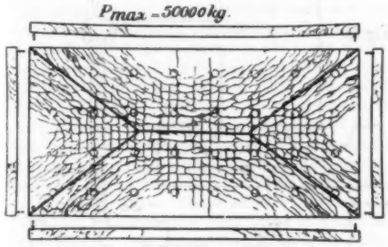
$$h' = r'\left[\sqrt{3+\left(\frac{r'}{R'}\right)^2} - \frac{r'}{R'}\right] \quad . \quad . \quad (8)$$

It may happen that in this way we get $r' > R'$, in which case the triangles of fracture have as bases

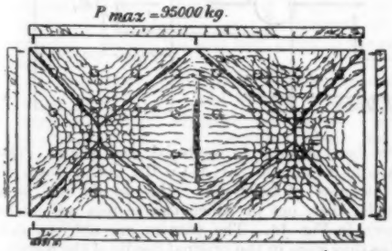
Fig. 7. $P_{max} = 44000$ kg



$P_{max} = 50000$ kg.



$P_{max} = 35000$ kg.



Assuming k-1

not a_1 and a_3, but a_2 and a_4, and we must then, in equations (6A), (6B) and (6C) substitute:

$$R' = \frac{h_1}{\sqrt{1+k_1}} = \frac{h_3}{\sqrt{1+k_3}} = \frac{2R}{\sqrt{1+k_1}+\sqrt{1+k_3}} \quad (14A)$$

$$h'' = \frac{h_2}{\sqrt{1+k_2}} = \frac{h_4}{\sqrt{1+k_4}} \quad . \quad . \quad (14B)$$

$$r' = \frac{2r}{\sqrt{1+k_2}+\sqrt{1+k_4}} \quad . \quad . \quad (14C)$$

whence

$$h'' = R'\left[\sqrt{3+\left(\frac{R'}{r'}\right)^2} - \frac{R'}{r'}\right] \quad . \quad . \quad (15)$$

If the values of k be assumed, the corresponding values of h can be found graphically in the following way (see Fig. 6):

Divide a_1 and a_3 by a line M M′ in two parts in the ratio $\frac{\sqrt{1+k_2}}{\sqrt{1+k_4}}$ a_2 and a_4 by N N′ in the ratio $\frac{\sqrt{1+k_1}}{\sqrt{1+k_3}}$. M M′ and N N′ intersect at O.

Draw the "diagonal" B′ O D′ through O at an angle determined by:

$$\tan v = \frac{\sqrt{1+k_1}+\sqrt{1+k_3}}{\sqrt{1+k_2}+\sqrt{1+k_4}} \times \frac{r}{R}$$

then:

$$M B' = \frac{\sqrt{1+k_1}}{\sqrt{1+k_2}+\sqrt{1+k_4}}\, b' \text{ and } M' D' = \frac{\sqrt{1+k_3}}{\sqrt{1+k_2}+\sqrt{1+k_4}}\, b.$$

We now repeat the geometrical construction already described in Fig. 4, and find:

$$A' E' = h_1 + h_3;\ F' D' = E F \text{ and } M E = h_2.$$

The breach diagram is composed therefore of the lines E F and the lines radiating from E and F to the corners of the slab.

Lastly we determine the bending moment from (9).

In case $\tan v > 1$; $v > 45$ deg.; we must carry out a similar construction, but this time on the long sides, *i.e.*, B C and A D.

The way the bending moment varies in the two directions of the slab will become more apparent on reference to Fig. 6A.

It will be seen that the B M in the centre of the slab fixed along the edges is the same as in the slab A′ B′ C′ D′ freely supported along the edges. If we assumed this to start with, another way of determining the bending moments in a slab fixed along the edges could be devised.

RESUMÉ.

1. The bending moment per foot run of a rectangular slab (length of sides, $l = 2R$, $b = 2r$), freely supported along the edges and carrying a load of p per sq. ft. may be determined by the formula—

$$m = \frac{1}{6}\, p\, h_1^2$$

in which

$$h_1 = r\left(\sqrt{3+\left(\frac{r}{R}\right)^2} - \frac{r}{R}\right)$$

The same formula may be used for any slab with 4 sides, provided only that the projection of the "centre" of the 4 sides fall on the sides themselves and not on the sides produced.

2. The bending moment per foot run of a rectangular slab loaded as above, but fixed along the four edges (the bending moments being $m_n = k_n\, m$), may be determined by the same formula, provided the lengths l_1 and b_1 be substituted for the lengths l and b.

l_1 and b_1 represent the distances between the points of contraflexure (where B M = O) in beams loaded, supported and fixed in the same manner as the slab and having the spans l and b respectively; this also applies to non-rectangular slabs as above.

3. The reaction along the edges is distributed in accordance with the figure of the breach; this is either a triangle or a trapezium. If the static moment round the corresponding side be S_n then

$$p S_n = m\,(l + k_n)\,.\,a_n$$

(To be continued.)

THE NATIONAL PHYSICAL LABORATORY.

(Concluded from page 194.)

We proceed with our comments upon the Heat Department.

Thermometry Division. (Dr. Kaye, Messrs. W. F. Higgins, M.Sc., and W. Hugo.)—The number of thermometers (of high, low and medium ranges) dealt with was nearly double that of last year. Mention is made in the reports of new types of dial thermometer, these having steel bulbs containing mercury connected by a steel capillary tube to a Bourdon gauge. The construction is not in itself novel, but in previous instruments of this type the temperature indications were not independent of the temperatures of the capillary and of the indicator; this independence has now been attained, a difference of 30 deg. being correctly recorded within 0·1 deg. by a capillary 12 ft. in length. The number of clinical thermometers tested in the year ending with September, 1920, was 1,597,339, giving an average of 30,000 instruments per week; actually up to 33,000 clinical thermometers have been tested in one week. There has been an improvement in the quality; the percentage of rejections, on average over 3 per cent. at the beginning of the year, (8 per cent. in one case), fell below 2 per cent. by the end of the year.

Radiology. (Dr. Kaye, Dr. E. A. Owen.)—The radiology division, formerly in Bushy House itself, is now housed in Elm Lodge, which stands apart from the main block of buildings. The British radium standard of 30 milligrammes of hydrated radium bromide being inconvenient for the standardisation of samples of 1 milligramme, two subsidiary standards of 10 milligrammes and 13·5 milligrammes have been acquired. The standardisation is effected by three methods; we have mentioned two on previous occasions. In the third, γ-ray method, due to Madame Curie, the radium is placed on the top of a large disc condenser, a shallow box made up of two sheets of lead, 80 cm. in diameter, 5 mm. thick, to stop all radiations except γ-rays; between the lead plates is an insulated aluminium plate, the electrode. The ionisation current produced by the sample is measured by the aid of a Curie "quartz-piezo-electric." This consists of a rectangular strip of quartz, 9·5 cm. long, 1·5 cm. wide, 0·58 mm. thick, cut in a plane at right angles to one of the three axis and in the plane of the optical axis, the short edge of the rectangle being parallel to the optical axis; a scale pan is suspended from the bottom of the quartz, to electrify the quartz by putting it under a tension load. Both faces of the strip are covered with tin foil to serve as armatures; the one foil is connected with the aluminium electrode, the other foil is earthed, and weights—of the order of 1 kg.—are put in the scale pan until the piezo-charge of the quartz balances the ionisation charge. The process is repeated with the radium standard; the piezo-charges and the radium contents of the sample and standard are directly proportional to the weights used.

Radium Luminous Compounds. Scattering of γ-Rays.—In these compounds zinc sulphide is mixed with a very small amount of radium salt, and it had been suspected that the γ-ray test of such mixtures would be influenced by an absorption of the rays by the sulphide, such that the tests made before and after mixing the sulphide and radium need not be in accord. This has been disproved. We should add that radium luminous dials are also tested by Mr. Walsh in the Photometry Department, the Laboratory working in this case in conjunction with the British Scientific Instrument Association, which makes and supplies the zinc sulphide. The Laboratory does not chemically analyse the sulphide, the slight impurities of which, it is widely believed, may be essential for luminous paints.

There is, however, another absorption which Dr. Owen is investigating. When penetrating γ-rays from RaC fall on metals, there is scattering and sometimes also a "fluorescent" absorption of the rays; this latter effect has been observed so far in aluminium, zinc, lead and tin. In these measurements both "forward" and "backward" scattering have to be determined and the distinctive measurements are difficult. Scattering has to be taken into account in all radium measurements; even an ordinary light wall will scatter the rays to a considerable extent, and apparatus for standardising radium should hence be placed in the middle of the room.

The Structure of Materials.—The X-ray spectrometer especially designed by Dr. Owen for the study of the structure of materials, metals in the first instance, is of the Bragg type. The instrument has been made by Mr. Murfitt in the Laboratory, the graduated circle (part of a theodolite), which reads to 5 seconds of arc, having been supplied by Messrs. E. R. Watts and Son. The instrument consists of a large box of lead (6 mm. in thickness) containing a Coolidge tube and all the high-tension appliances; the box is provided with lead glass windows (with lead shutters) and devices for making adjustments from outside; the box is earthed. The X-ray beam which falls on the crystal face passes through two slits, and the beam, reflected by the crystal, enters the ionisation chamber by a third slit. This third slit and the ionisation chamber itself are subdivided, so that the top portion of the beam is sent into the upper chamber, and the bottom portion into the lower chamber. One of the chambers is used as standard;

the ionisation in the other chamber is produced by rays which have passed through the metal under examination. The X-ray bulbs used in this research are provided with anti-cathodes of various metals, tungsten, palladium, rhodium, silver, copper, nickel and platinum.

Intensity of X-Rays.—In the measurement of the intensity of X-rays use is made of the pastilles of barium platino-cyanide of Sabouraud and of other makers; the colour change is observed while varying and measuring the volts and amperes of the currents, the rate of interruption of the primary, length of time of make and type of interrupter.

Electricity Department.—The resignation of Mr. F. E. Smith, F.R.S., late superintendent of the Electricity Department, who last year accepted the post of Director of Scientific Research at the Admiralty, is a severe loss to the Laboratory, equally regretted by the Executive Committee and by all his colleagues. Mr. Smith was one of the original staff members of the Laboratory. He became responsible for the continuation of the work of the British Association Committee on fundamental electric units and primary standards, and one feels almost sorry that he should have proved himself as capable an administrator as he was an original and resourceful investigator. If he had not shown himself so good a superintendent, the Admiralty officials, with whom war work brought him into contact, might have left him to his research work. Fortunately his connection with the Laboratory is not severed; as the Admiralty research building has been erected on the Laboratory grounds, the Report expresses the hope that the Laboratory will continue to benefit from his advice and assistance. Another superintendent has not been appointed.

Fundamental Units.—Professor G. W. O. Howe, late of the City Guilds Central College, South Kensington, is now in charge of this division. The Report for 1920 gives a brief summary of the work done on units since 1914, when Dr. Giebe had come over to Teddington from the Reichsanstalt to conduct an absolute measurement with the Lorenz apparatus of the Laboratory, bringing with him some standard coils. According to the latest determination by Grüneisen and Giebe the length of the mercury column of 1 ohm would be 106·246 cm.; F. E. Smith's value of 1913 was 106·245 cm., and the average of the most reliable determinations is 106·245 cm. The most probable value of the international ohm would then be 1·00052 ohms 1 volt = (10^9 c.g.s. units) and the electromotive force of the Weston normal cell would at 20 deg. C. be 1·0183 volts (10^8 c.g.s. units). It is pointed out that it is time to revert to the ideal of 1863 and to measure all electric quantities in c.g.s. units, *i.e.*, to employ the ohm, ampere, volt without qualification. As regards the Weston normal cell, cells made at Teddington have been sent to America, France and Japan for comparison; the Weston (cadmium amalgam) cells are the most constant, but they have their peculiarities.

General Electric and Magnetic Measurements. (Messrs. D. W. Dye, L. Hartshorn, S. Butterworth.)—In measuring the magnetic permeability and energy losses of thin sheet iron at radio frequency, the iron rings are made up into an inductance of toroid form (like an armature) and are wound with a single layer; by inserting this wound ring in a wavemeter the effective inductance and effective resistance are determined. This simple method has been found very useful. Mr. Dye has also developed a very accurate ballistic galvanometer method of measuring the capacity of condensers in terms of a mutual inductance and resistance; the method avoids the double-kick of the Carey-Foster method, though it necessitates comparison of two practically equal throws. His virtual earthing device for the measurement of small air condensers on Carey-Foster bridges is based upon the earthing system of K. W. Wagner for inductance bridges. The point is to eliminate errors due to the capacities of the earth and of the telephone. Fig. 13 explains the arrangement. Both the resistance R and the inductance L, as well as the mutual inductance M, are variable; the former are shunted across the supply leads to the bridge; O, not O_1, is the point to be earthed. In taking a measurement an approximate balance is first obtained. The telephone terminal *a* is then disconnected from the bridge and connected to the point O; a balance is obtained by adjusting L_1 and R_1; when this has been effected the telephone lead is replaced on *a*, and the final bridge balance is obtained, while the telephone is virtually kept at earth potential.

In determining high resistance at high frequency, *e.g.*, 400,000 ohms at 30,000 periods per second, the condenser of a tuned wavemeter is first shunted with the unknown resistance, and the maximum current is observed. The high resistance is then removed and a fine-wire low resistance is added in series to the wavemeter and adjusted until the same current is obtained at resonance.

Mr. Butterworth has simplified the calculations of the constants of the ampere balance, the Lorenz apparatus, and the Campbell standard of inductance, and he has also investigated the errors arising in alternating current bridge measurements due to impurities in mutual inductances; the errors arise when the electromotive force in the secondary is not in exact quadrature with the primary current. By using the results of three sets of bridge measurements, the Carey-Foster bridge, a modified Campbell bridge and an Anderson bridge, he has been able to separate the effects of the condenser power factor and of impurity in the mutual inductance. Mr. Butterworth presented a paper on these problems to the Physical Society in June last.

Fig. 13.

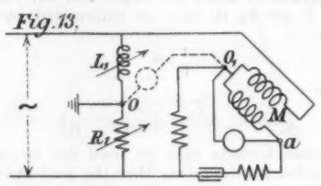


Fig. 14.

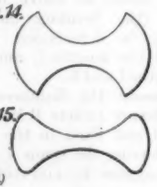
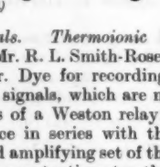


Fig. 15.

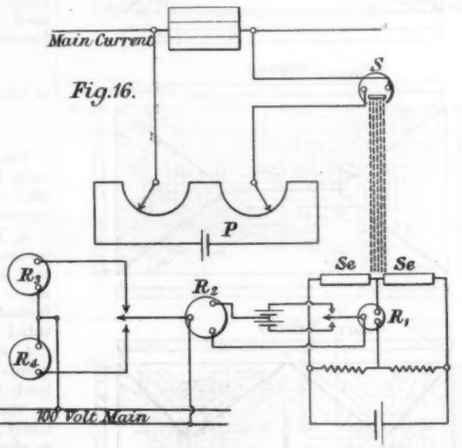


(6371.)

direction-finding coils which Mr. F. E. Smith proposed early in the war, and which did not find favour until similar devices came over from other countries, were on exhibition together with later apparatus.

Electrotechnics. Alternating Current Measurements. Electrostatic Meters. (Principal assistant, Dr. E. H. Rayner, M.A.; Mr. R. Spilsbury.)—Owing to the retirement of Mr. Kinnes and Mr. Stamp the department has been very short-handed, while the routine work, especially as regards instruments for acceptance tests of steam turbo-generators, has much increased. In these tests Mr. Spilsbury uses a high-ratio transformer to magnify the departure from perfection, the electrostatic wattmeter serving as indicator. Stray magnetic fields have to be carefully avoided; even when the transformer is several feet away from the source of heavy currents an appreciable voltage may arise in the secondary, though the primary is not in use. The slightly imperfect needle of the wattmeter has been improved, special steel discs being used for the stiffening ribs instead of the former brass discs; the total thickness of the needle, including these ribs, must remain below 0·5 mm. In the Kelvin electrostatic voltmeter, redesigned by Dr. Rayner, and made in the Laboratory, the torsion control is replaced by a bifilar suspension, and the 10 needles, fixed above one another, 8·7 mm. apart, on a tungsten wire by means of distance pieces of aluminium,

Fig. 16.



Time Signals. Thermoionic Valves for Radiotelegraphy. (Mr. R. L. Smith-Rose.)—The apparatus set up by Mr. Dye for recording the French and German time signals, which are now received regularly, consists of a Weston relay shunted across a high resistance in series with the last valve of a rectifying and amplifying set of thermoionic valves; by means of a potentiometer the relay current is reduced to zero when no signals are received.

The investigation of the characteristics of thermoionic valves, begun under Mr. F. E. Smith, has been the chief subject of research by Mr. Smith-Rose. Mercury condensatory pumps are used to produce the highest evacuation; they are associated with a Gaede molecular pump and ordinary pumps as backing pumps. The vacua obtained, probably of 0·01 bar (1 bar = 0·00075 mm. of mercury), can no longer be measured by McLeod gauges, and the use of Knudsen gauges is contemplated. This work on the characteristics of the valves involves the study of the influences of residual charges of various gases at different internal pressures; one of the points to be investigated is the damage done to the filament by the impact of heavy atoms like argon; in gases the characteristics also show peculiar kinks. Direction-finding is at present the chief problem, as we pointed out in our notice of the Royal Society Soirée last May, where Mr. Smith-Rose exhibited the coils now in use for this purpose. The difficulty is that the bearing of the sending station is not always truly indicated by such apparatus; there are atmospheric (solar) and possibly local influences, to study which coils have been set up at the different universities of the kingdom. At the National Physical Laboratory, on the inspection day some have been altered in material and shape. The material is an alloy of Al-Cu-Mn, rolled down to a thickness of 0·02 mm.; the needle now is a circular disc, out of which two sectors are cut as shown in Fig. 14. The corners are not rounded off as they were in the original needle of the Kelvin-White instrument shown in Fig. 15, the advantage being that the scale is opened out at the extremities as compared with the centre. The needles are cut with a knife between two templets of brass. The mirror is attached to another wire, hooked on the wire suspension below the needle system, and a damping disc immersed in oil hangs down from the mirror frame. The whole suspended system has a length of 400 mm. and weighs 2·6 grammes, the 10 needles together weighing 0·3 grammes and the mirror (20 mm. in diameter), 0·6 gramme. The instrument measures up to 130 volts on a scale 8 m. long. One of the problems under investigation is the tendency of transformer oils to produce sludge.

Photometry. Ships' and Miners' Lamps. (Dr. Rayner, Messrs. J. W. T. Walsh and H. Buckley.)—The standardisation of lamps and the provision of sub-standards for gas-filled lamps has been delayed by other work and also in view of the contemplated meeting of the International Commission on Illumination. An 8,000-c.p. lamp, gas-filled, for currents of 50 amperes at 80 volts, for light-house work, was one of the exhibits on the inspection day. The spiral filaments are grouped in a kind of pyramid; the globe has a diameter of 12 in., and there are two sets of leads in parallel to carry the heavy currents. As regards ships' navigation lamps various simple suspension devices have been designed for ready testing, and an experimental lens (for mast head and

side lights) has been constructed with top and bottom prisms at variable angles. The investigation of the miners' lamp has now been extended to electric lamps, and experiments on mitigation of the glare of motor-car headlights have been resumed. The new sphere photometer under construction consists of a cast-iron mine case, 1 m. in diameter, which is split equatorially, the two halves being bolted together. The wall inside is lined with an inch of cement in which wire netting is embedded; the surface is painted with zinc white or some other non-selective paint. The upper half has a circular opening into which the holder of the lamp to be tested fits; the lamp itself is lowered into the sphere in which it remains stationary whilst it can be turned and inclined in various directions in other photometric devices. The observer looks through an opening in the equatorial region, not directly at the lamp, which is shielded, but at the different parts of the wall, so as to study the spherical distribution of the light.

Illumination of the National Gallery and Houses of Parliament.—In order to study the illumination of the National Gallery a scale model hut, one-third full size, was erected on the open space at the back of the building and measurements of the wall illumination were taken, direct sunlight from windows or skylights being avoided. The problem of securing light for the examination of pictures, while eliminating reflection from the glass covering the picture, is different for a gallery running east-west and for a gallery running north-south. The problem was first studied in the hut running E.W.; afterwards the hut was turned through 90 deg. The middle third of the ceiling was covered: a vertical screen placed outside over the ceiling kept the sunlight off the pictures on the north wall; this screen was painted white on its north side to reflect the light of the sky, and in this way a suitable illumination was attained. As regards the House of Commons, the intensity and colour of the light had been made as much as possible the same as in the old Argand gas lamps, when electric lamps were adopted a generation ago; when Dr. Rayner took up the inquiry, the illumination was on an average very low, less than the equivalent of a candle at a foot, whilst three times that light is usually considered necessary for reading manuscripts. An increased illumination was recommended and adopted. Advice has also been given in the case of other public buildings.

A satisfactory substitute for Nernst galvanometer lamps has been found in the Aldis daylight signalling lamp, supplied by Messrs. Siemens Brothers. These are gas-filled lamps, for 2·5 amperes at 10 volts, bulb diameter about 50 mm., containing a double spiral filament forming an oblong mounted in a vertical plane.

Direct-Current Measurements. (Mr. S. W. Melsom, Mr. H. C. Booth.) *Buried Cables.*—The research on buried cables, an interim report on which was presented to the Electrical Research Association last year and was discussed by the Institution of Electrical Engineers in London and in its provincial sections, has developed into a big thing. It is now proposed to work on groups of cables in the same duct or nest to study dielectric losses and ageing, and the effect of prolonged heating, for years, to 100 deg., on the properties of dielectrics with the cables at potentials of 20,000 volts. The plant required for this investigation is already installed or ordered. There are two 80,000-volt transformers and special feeding boxes for the three-core cables, to be tested in lengths of 15 ft. Preliminary tests are made in electric ovens, spiral leads being used to secure good contact.

Selenium Current-Regulator.—The selenium regulator for the currents of 5,000 amperes for this cable work was mentioned by us last year; we now illustrate it in the diagram, Fig. 16. Leads from the standard resistance used in these measurements are brought to a regulating potentiometer circuit P. The galvanometer G is enclosed in a cardboard cover and is fitted with adjustable stops. The two selenium cells Se are so mounted in front of the galvanometer that, when the current is either too high or too low, the light illuminates either of the two cells. These cells form two arms of a Wheatstone bridge, the other two arms being made up by a plug-resistance box; 4,000 ohms roughly correspond to the dark resistance of a selenium cell. A sensitive moving coil relay R_1 is connected across the galvonometer terminals in circuit with a battery of 15 small accumulators. There is a further relay R_2 working the final relays R_3 and R_4 on a 100-volt main, R_3 throwing in resistance into the generator field and R_4 cutting resistance out. The selenium responds very quickly to the light, and the arrangement will keep a current of 1,000 amperes constant within 0·2 per cent. for a day. By stiffening the galvanometer suspension an increased sensitiveness is secured, and the arrangement has the advantage that the operating forces are very small. Unfortunately selenium has its peculiarities, and the cells have to be readjusted after periods of 10 hours or so.

Manganin (Ohmal).—The ohmal (manganin) standard resistance of the Laboratory was briefly described in our notice of the Royal Society Soirée of last May, when it was exhibited with specimens of the ohmal alloy. The secular changes in the alloy are still being investigated.

Bus-Bars, Contact Resistance and Heating.—The investigation concerning the contact resistance of clamped and bolted bus-bar joints, the thickness, overlap and pressure of such joints, and their heating having been conducted for a private concern, the British Aluminium Company, particulars are not published. This is regrettable, as some of the results were rather unexpected. Both aluminium and copper bars have been examined.

Optics Division. (Principal assistant, Mr. T. Smith, B.A.; Mr. J. Guild, Dr. J. S. Anderson, M.A.)—While Admiralty work has fallen off, the numbers of sextants, theodolites and levels, &c., submitted by private firms have increased very considerably, partly owing to the resumption of survey work. The Rheinberg graticules have facilitated the sextant bench work (Mr. W. J. Boxall). One of the systematic researches to be taken up is the determination of the temperature coefficients of the refractive properties of commercial optical glasses. For this research, as well as for progress in polarimetry and saccharimetry, a constant-temperature room with thermostatic equipment and brine circulation is needed. Papers on phenomena connected with optical setting have been published, and investigations of the personal errors of setting cross lines on the edge of bands of light, as in "critical angle" refractometry, and of the setting of diagonal cross wires on a vertical line are in progress. All types of setting applicable to optical instruments are to be inquired into, and the research will involve very extensive and laborious observations.

Measurements of Angles. Loss of Light. Grating Tests.—We mention finally a few of the devices which were demonstrated on the inspection day. In measuring angles of prisms use is made of two telescopes and a collimator, so set at 120 deg. apart about a small central table, on which the prism is placed, that the direction of the rays reflected from the two prism faces can be determined. In a more accurate but complicated modification of this substitution arrangement, the two telescopes are replaced by two plane mirrors, to the left and right of the observer; the luminous object is a wire, in front of which a variable wedge prism is so mounted that a very slight movement in the line of sight produces a big shift in the image; by turning a wheel at the eye end the observer pulls the micrometer carriage across the line of sight. Gratings are examined by a Michelson interferometer arrangement similar to that of Messrs. A. Hilger which we recently described; the observer sees directly the grating and the more or less irregular serrated lines. The amount of light transmitted and lost by a range-finder is determined in the following way. The light from a ground glass screen, uniformly illuminated by lamps behind, enters at the one end of the range-finder tube; it passes down the tube, and is examined by means of an optical pyrometer through the object glass in the middle of the tube; the pyrometer (or the source of light) is then transferred, and a direct reading is taken; if α_1 and α_2 are the two pyrometer readings, then $\tan^2\alpha_1/\tan^2\alpha_2$ gives the light transmitted. This ratio will be something between 20 per cent. and 40 per cent., about 70 per cent. of the light being lost by transmission and reflection in such instruments.

A very simple manner of testing the definition of a photographic lens was also shown. The lens is turned about a nodal point, and the distortion of the image, say of a window behind, is observed. Colorimeters of the Lovibond and other types were explained, and a curious experiment of Mr. Guild's proved that a surface of glycerin, left to itself for weeks, will not assume a perfectly plane surface; an optical plane, fixed just a little above the glycerin, showed irregular interferences.

We should state, in conclusion, that Mr. F. J. Selby, M.A., one of the original members of the staff, remains the Secretary of the Laboratory.

THE LUMSDEN SYSTEM FOR LATHE-TYPE TOOLS.

(*Concluded from page* 186.)

The lathe-type tools with which we dealt in our issue of July 29 (p. 183 *ante*), are all of the type having a straight or flat inclined top face or rake. In recent years there has arisen a considerable demand however, for tools having a curved top face. This form is preferred by many engineers for several reasons, and, in places, is by far the more popular type, as, for instance in large parts of the Continent. The ordinary method of producing such curved faces is, of course, by hand, but to meet the demand the Lumsden Machine Company have put on the market two appliances by which such tools can be ground to definite curves, and any required curve repeated.

Three chief claims are advanced for curved face, as against flat face, tools, of which at least two are worth some consideration. It is known now that, other things being equal, the breaking down point of a tool under work is dependent upon the cooling of the tip, and the amount of metal there is to carry the heat away. In this respect the curved top face has a great advantage, for the amount of metal cut away in grinding such a face back from the cutting edge is greatly reduced compared with a flat face. It is, in fact, a case of comparing a curve with the tangent to that curve at the cutting edge. As the latter is prolonged away from the edge, it cuts deeper and deeper into the tool and necessarily, if carried back any distance, weakens the tool considerably and reduces its heat-conducting powers. The curved face, it will be realised at once, does not suffer this disadvantage to nearly the same extent, for equal angles at the cutting edge.

In the next place the curved top face is held, with a good deal of reason, to give a good lead to curl the chip off the tool. There is no shoulder up against which the chip has to break, and in heavy work especially this assistance to the chip is considered to be of some considerable value, so that not only is the work cleaner as the sheared metal does not tend to crowd in front of the tip to the same extent, but the power absorbed in the cut is said to be less to an appreciable amount. This third point has not, it must be admitted, been definitely established, but there are reasons for believing it to be so, and it would be interesting if tests could be carried out to ascertain whether or not the saving is worth considering. Examples shown in Fig. 7, page 214, are tools from the chart given on page 185 *ante* in Table I (Nos. 6, 2 and 11 from left to right), ground, however, with curved top rake. Many of the other forms in this chart are also suited to this treatment.

In order to get different degrees of curvature with the same wheel, the Lumsden Machine Company make use of the fact developed in Fig. 8. This figure shows a standard cup wheel in various profiles, starting on the left hand with an outline at right angles to the axis and passing through various phase angles till at the right hand is a profile parallel to the axis and at right angles to the view on the extreme left. This gives a range of curvatures varying from the circumference of the disc down to the small radius which actually forms the outer edge of the wheel in longitudinal cross-section, and this is taken advantage of by making the tool travel along lines which correspond with some of the aspects thus obtained. In practice only the smaller angular positions are used such as 10, 15, 20 and 25 deg., but this is only a matter of practical convenience, and they do not exhaust the possibilities of variation.

This principle of utilising the varying curvature of the aspect ellipses was first utilised by the Lumsden Company in an attachment, which they provided for grinding curved faced tools on the oscillating tool grinder, described in the previous article (p. 183 *ante*). The attachment is shown in Fig. 9, page 214, in which the tool-holder previously described will be recognised mounted on the turntable. The attachment consists of a slide mounted on the universal tool-holder. This slide carries a clamp for the tool, which can swivel on

the slide. The clamp or tool-carrier has to be set so that the cutting edge is parallel with the slide; the turntable is set at 42½ deg. (for right hand tools), and the slide is set to give the required curvature, the wheel not oscillating during grinding and the tool being fed past the edge along this slide by means of the small lever, pinion and rack, seen in the figure. It will be evident from Fig. 9 that as the slide is swung into positions more and more nearly approaching the horizontal, the curvature ground would become larger and larger, till a curve, on the horizontal, identical with that of the periphery, would be obtained.

While this attachment suffices for a small amount of work, it cannot cope with the large quantities often necessary in the tool room of a large shop, and for this reason, the same principle has been developed further and embodied in the Lumsden curved rake tool grinder, which was first illustrated at the time of the Machine Tool & Engineering Exhibition at Olympia held last autumn, and which enables repetition tool grinding of this kind to be done on a large scale. The pattern we now illustrate in Fig. 10 to Fig. 13 on this page, is a machine in which the curved rake tool grinder, at one end is combined with a plain cup-grinder at the other, this combination having been found to be very serviceable, as the cup wheel can be used for rounding off and touching up, &c. The machine, it will be seen, consists of a pillar-base at the upper end of which is mounted, in ball bearings, the wheel spindle driven from below, a ball-bearing countershaft being attached to the base of the machine as shown in Fig 12. Ball thrust bearings are fitted to the wheel spindle. The cup wheel end does not present any features of special note in our present connection, though attention may be drawn to the self-contained wheel dresser, and the belt-driven pump and tank below the pan. Fig. 12 shows the controls of the curved rake grinder end, a short lever at the wheel spindle level being the belt shifting lever, while the handwheel on the slanting spindle, and the grip lever to the left of Fig. 12, are both for operating the tool-holder. The first raises the tool-holder towards the wheel, and thus provides "feed"; the second traverses the tool-holder across the wheel edge. The tool-holder which is contained in a deep pan, is shown more clearly in Fig. 10 and Fig. 11; in the latter for sake of clearness the tool-holder has been removed from the pan.

The tool-holder or vice consists of a mounting set

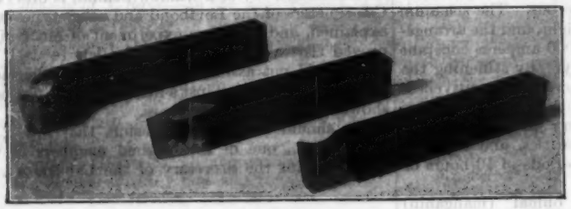


Fig. 7. Examples of Curved Faced Tools.

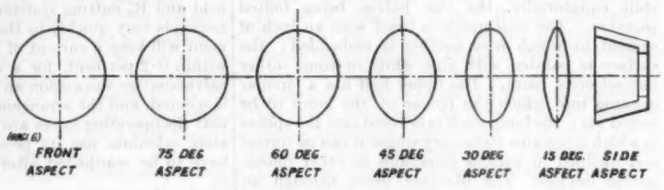


Fig. 8.

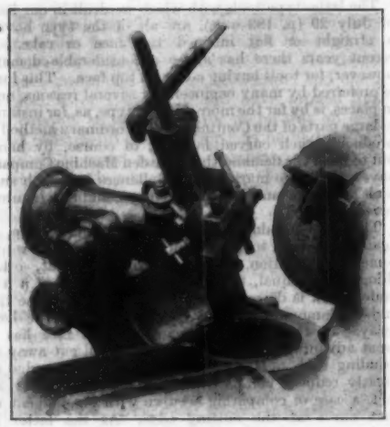


Fig. 9. Curved Face Attachment for Oscillating Tool-Grinders.

Fig. 10.

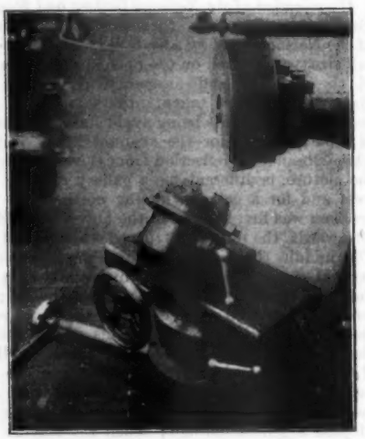


Fig. 11.

Figs. 10 and 11. Tool-Holder and Turntable of Curved Rake Tool-Grinder.

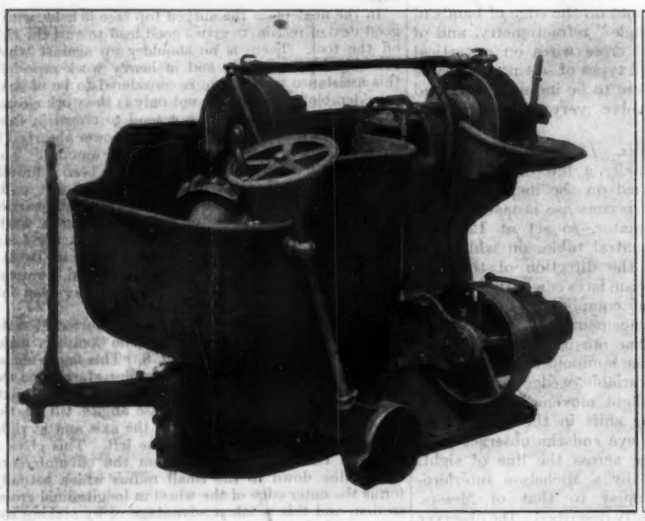


Fig. 12.

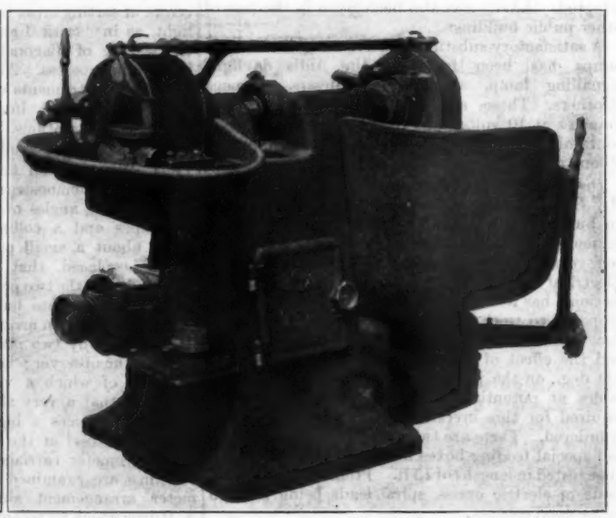


Fig. 13.

Figs. 12 and 13. Lumsden Curved Rake Tool-Grinder.

THE LUMSDEN SYSTEM FOR LATHE-TYPE TOOLS.

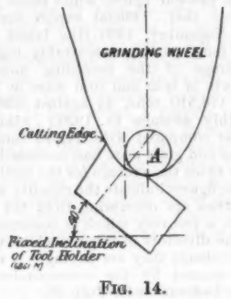


FIG. 14.

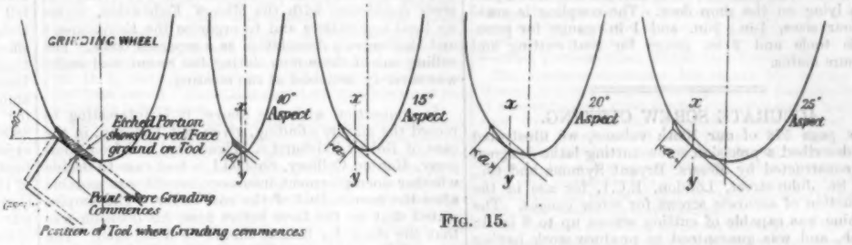


FIG. 15.

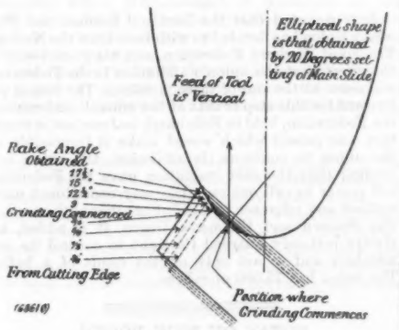

Elliptical shape is that obtained by 20 Degrees setting of Main Slide
Feed of Tool is Vertical
Rake Angle Obtained.
Grinding Commenced
From Cutting Edge
Position where Grinding Commences

FIG. 16.

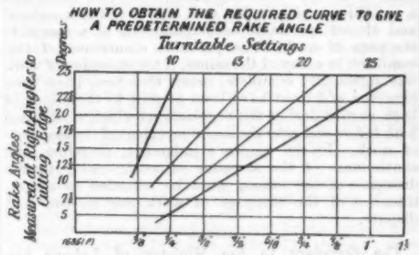


FIG. 17.

permanently at an angle of 40 deg. to the horizontal. This vice is mounted on a vice turntable—a small swivelling mounting which enables the vice to be swivelled in its mounting through 180 deg.—and clamped, where necessary, by a small knob-handle to a setting on a graduated circle. This part of the apparatus is carried on a compound slide of which one motion called the cross-motion is in a direction in vertical alignment with the axis of the 40 deg. tool-holder, and is controlled by the small handwheel shown. The second or traversing slide is arranged immediately below and at right angles to the cross-slide, and the movement for this is provided by the long grip lever already mentioned, the pivoted end of which is shown in Fig. 11. The lever and spindle are fitted with a notched adjustment cap, so that the lever can always be brought to a position convenient for manipulation. Two further adjustments are arranged for. Vertical adjustment by the exterior handwheel has already been mentioned, while finally the whole compound slide can be swivelled through 180 deg. on a vertical axis and clamped to any setting on a graduated circle, by a small lever which will be easily recognisable in Fig. 11.

The grinding wheel is of the short cup form, 12 in. or 14 in. in diameter, with a slightly rounded corner. The view in Fig. 10 will show how the tool is mounted for grinding, and with the foregoing remarks regarding Fig. 8, it will become evident how different curvatures are obtained, the tool being traversed in a more or less diagonal direction across the path of the periphery according to the degree of curvature to be aimed at. The diagonal path is set by means of the turntable, a somewhat exaggerated setting being shown in Fig. 11 to make the motion clear. A tool, as shown in the vice in Fig. 10, after clamping, is set so that the cutting edge is parallel with the main traversing slide. This is, of course, ensured by making the necessary swivelling adjustment of the vice turntable. The main slide is set to the degree required to give the necessary curvature, and the tool is then elevated so as nearly to touch the wheel. The cross-slide is then used to bring the tool close into position and the tool is then ground by traversing the main slide. In practice, a combination of elevating and traversing motions is frequently used.

Fig. 14 shows the type of face ground on the tool, held in the vice set at 40 deg. At the cutting edge the curvature is not great, but further it increases until it is virtually equivalent to that of a small radius circle A. By this type of curve it is possible to get the required cutting angle without grinding unduly far back on the top face.

The effect of employing an elliptical aspect for the grinding wheel is further developed in Fig. 15. Here, on the extreme left, is shown a typical setting, with the tool in position indicated, shown in full lines at the moment of commencing grinding, and in dotted lines after feeding vertically and the face completed. The hatched portion shows the amount ground away. The other diagrams show wheel aspects of 10 deg., 15 deg., 20 deg. and 25 deg.—the regular settings—and below are shown corresponding tools in the positions of before and after grinding. This series gives comparative representations of the variation of curvature obtained with vertical feed (xy) and different turntable settings, and indicates also that for different curvatures or rakes the point at which grinding commences must be varied.

The latter point is followed up in Fig. 16, in which it is shown that with one wheel setting the rake can be altered by varying the distance back from the cutting edge at which grinding commences. This must be obvious in itself, from considering on one hand the extreme of commencing to grind at a point where the 40 deg. line is a tangent to the ellipse, when no rake would be obtained and only the end of the tool stepped down, and, on the other, grinding at a point very far back, when it is clear an extreme rake would be the result, owing to the tangent to the ellipse approaching more nearly the vertical. This point is illustrated over a small range in Fig. 16, in which four tool positions are shown. The first position is one in which grinding is commenced $\frac{3}{8}$ in. back from the edge. The resulting top face will have a rake angle of 9 deg. If grinding be commenced $\frac{1}{4}$ in. back, a rake of 12½ deg. is obtained. If the distance back from the face be increased by $\frac{1}{8}$ in. more, the rake obtained is 15 deg., while if $\frac{3}{8}$ in. is adopted, the angle of rake becomes 17½ deg. The foregoing are with a 20 deg. setting for the turntable of the main slide, and vertical feed of the tool.

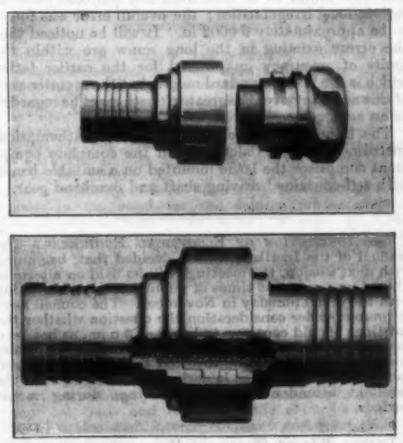
TABLE II.

Turntable Setting.	Degrees of Rake.								
	5	7½	10	12½	15	17½	20	22½	25
	Distances back from cutting edge at which grinding must commence.								
deg.	in.	in.	in.	in.	in.	in.	in.	in.	in.
10				$\frac{1}{8}$	$\frac{3}{16}$	$\frac{3}{16}$	$\frac{3}{16}$	$\frac{1}{4}$	$\frac{3}{16}$
15			$\frac{3}{16}$	$\frac{1}{4}$	$\frac{3}{16}$	$\frac{1}{8}$	$\frac{3}{16}$	$\frac{1}{8}$	$\frac{3}{16}$
20		$\frac{1}{4}$	$\frac{3}{16}$	$\frac{1}{8}$	$\frac{1}{8}$	$\frac{3}{16}$	$\frac{1}{8}$	$\frac{1}{8}$	
25	$\frac{3}{16}$	$\frac{3}{16}$	$\frac{3}{16}$	$\frac{1}{8}$	$\frac{1}{8}$	$\frac{1}{8}$			

The range of curvature obtainable by a combination of these methods is very large, but for working purposes a simple chart or table can be made to cover the practical settings, giving the points at which grinding has to commence for any desired rake angle. Such a chart is given in the accompanying Fig. 17, in which rake angles are ordinates and distances from the cutting edge are the abscissæ. The four straight-line curves are respectively for 10 deg., 15 deg., 20 deg. and 25 deg. settings of the turntable. As an example, a tool of No. 4 shape (Table I) of 1 in. by 1¼ in. section has to be ground for 15 deg. rake. The chart indicates that this can be accomplished with a turntable setting of 20 deg., commencing to grind $\frac{1}{8}$ in. back from the cutting edge. The same information is given in Table II in the previous column. In this case the figures are close approximations only, but are quite near enough for all practical purposes, and often the operator will probably prefer figures to a chart. The table accentuates the fact that one angle of rake may be obtained with various turntable settings, but involves with the larger aspects, a larger ground top face. In the ordinary way, of course, it is desirable to keep this short so as to save grinding away too much steel behind the cutting edge weakening the tool and lessening its power of conducting away the heat generated in cutting.

PNEUMATIC HOSE COUPLING.

A SIMPLE, ingenious and neat form of coupling for pneumatic hose has been introduced by Messrs. Belliss and Morcom, Ltd., of Ledsam-street Works, Birmingham. It was designed to meet a want which was felt in Messrs. Belliss and Morcom's own works, for a coupling which would give no trouble and it has proved, we understand, entirely satisfactory. Its construction will be followed from our illustrations of which Fig. 1 shows the two separate parts of a coupling intended for joining a hose to a cock or fitting, and Fig. 2 the assembled parts of a coupling for joining two lengths of hose. The coupling is partly cut away in the latter figure



FIGS. 1 AND 2.

to show the construction. The parts are made from steel bar, coslettized to resist rust, and they fit one inside the other as shown in Fig. 2. The male part, shown to the right in Fig. 1, has a pair of projecting lugs, which engage a bayonet clip arrangement on the female part, so that when coupling up it is only necessary to place one part inside the other and give a quarter turn. There are no steel springs or other details in connection with the lock, and the internal pressure has no tendency to blow the parts away from each other.

The actual air joint is made by a rubber sleeve fitting inside, but projecting from the male part as shown in Fig. 1. This can be seen in section in Fig. 2, which also shows the method by which it is secured. Near the bottom of the recess in the male member, in which the rubber sleeve fits, a half-round groove is turned and the sleeve material is forced into this groove by a spring ring resting inside the sleeve. The diameter of the ring is such that the rubber sleeve is held securely, but there is no difficulty in getting the ring in place or removing it when it is desired to insert a new sleeve. It will be seen from Fig. 2 that the internal air pressure in the pipe acts to keep the rubber joint tight and that there is no tendency for the sleeve

to be blown out, or off its seat. The coupling is little larger in outside diameter than the hose it joins and as it has no outside projections it offers no hindrance to work in close quarters, or when it is being drawn past work lying on the shop floor. The coupling is made in four sizes, ¼-in., ⅜-in. and 1 in. gauge for pneumatic tools and 2 in. gauge for coal cutting and pressure mains.

ACCURATE SCREW CUTTING.

On page 578 of our 105th volume, we illustrated and described a precision screw-cutting lathe designed and constructed by Messrs. Bryant Symons and Co., 320, St. John-street, London, E.C.1, for use in the production of accurate screws for screw gauges. The machine was capable of cutting screws up to 8 in. in length, and was guaranteed to produce work having a total length pitch error within 0·0004 in., a progressive error within 0·00015 in. per inch and a periodic error within 0·00015 in. Within the last few weeks, Messrs. Symons have constructed for the India Office a lathe of similar design but capable of taking work up to 27½ in. long between centres and of cutting screws of just over 25 in. in length.

The interesting feature of this lathe is that the high degree of accuracy reached in the earlier tool has been well maintained throughout the whole length of the work produced by the latest model. To test the accuracy, a trial rod 1 in. in diameter and having an overall length of 27½ in. was cut with a right-handed screw, having 10 threads per inch, for a length of 25½ in. This screw was submitted to the National Physical Laboratory for measurement with the following results: Measurements were made at ½ in. intervals along one generator line and repeated at 3 in. intervals along a second generator line on the opposite side of the screw. The errors were found to lie within limits of ± 0·0004 in. throughout the whole length of the screw, and measurements made at consecutive threads over a length of 1 in. disclosed pitch errors within the limits ± 0·0001 in.

Another short screw, ½-in. in diameter and 3 in. in overall length, screwed with a left-handed thread having 36 threads per inch for 1 in. of its length, was also tested. This was measured at consecutive threads and was found to be free from any periodic error or serious local irregularities; the overall error was found to be approximately 0·0002 in. It will be noticed that the errors existing in the long screw are within the limits of accuracy guaranteed for the earlier lathe, which is the firm's standard model, but the maintenance of this accuracy over the greater length must be regarded as an achievement of a higher order.

The lathe is to be employed at the Mathematical Instrument Office, Calcutta, and the complete equipment comprises the lathe mounted on a suitable bench with self-contained driving shaft and overhead gear.

The Institution of Electrical Engineers.—The Council of the Institution have decided that, beginning with next session, the meetings will be held on alternate Thursdays (except at times of public holiday), beginning with the first Thursday in November. The council have at present under consideration the question whether the meetings should continue to begin at 6 p.m., as has been the case during the last few years, or whether the former hour of 8 p.m. should be reverted to. We are inclined to think that no change is desirable, having in view the excellent attendance at the meetings during recent sessions.

Imatra Rapids (Finland) Power Schemes.—Some details of the hydro-electric possibilities of the Imatra group of rapids which constitute one of the largest water powers in Finland, and the largest on the River Vuckseu between Lakes Saima and Ladoga, have been sent to the Department of Overseas Trade by the British Vice-Consul at Wiborg. The Imatra system, if fully developed, is calculated to yield 150,000 h.p. A decision to begin the development was reached at a conference held at Imatra on May 9 last. This conference was attended by the Ministers of Interior, Industry and Transports, as well as several prominent engineers. It was decided to expropriate the land that will have to be flooded and to begin work about 1922. In the meantime, however, 20,000,000 Finnish marks have been appropriated in the budget for 1921, and this sum is being expended in connection with preliminary work. It is estimated that the total cost of this project, including the land that has to be purchased, will amount to 267,000,000 marks, and that the work will require eight years for completion. Ritikka, Mansikka, Ranankoski, Linnankoski and the big Imatra Falls, are included in this project. These rapids are distributed over a distance of 4½ km. and have a fall of 24 m.; the Imatra provides a fall of slightly over 18 m. Linnankoski has a fall of about 5 m., and 1 m. will be obtained from the three falls above Linnankoski. The present scheme calls for a dam above the Imatra Falls with a head of about 6 m., and a power canal which requires the removal of 700,000 cub. m. of earth and rock. The water is thus to be led to a power-house situated below the Imatra Falls, with potential energy of a fall of 24 m.

INDUSTRIAL NOTES.

At a recent meeting of South Wales colliery enginemen, stokers and surface craftsmen it was decided to sever connection with the Miners' Federation, to set up local committees and to organise the Enginemen's and Craftsmen's Association as a separate body. The calling out of these men during the recent coal strike was severely criticised at the meeting.

In connection with the above, it is interesting to record the umpire's finding, given last Tuesday, in the case of Robert Fairhurst *v.* Wigan Coal and Iron Company, Manton Colliery, Sheffield, a test case to decide whether unemployment insurance benefit was payable after the termination of the coal strike. The umpire stated that on the facts before him, his decision was that the claim for benefit should be disallowed. The state of disrepair into which the mines had fallen was a condition which in the coal industry was a natural and almost inevitable accompaniment of a complete stoppage of work. The probable occurrence of this condition in many of the mines, if the stoppage of work was sufficiently complete, must, therefore, have been expected and must have been present to the minds of both parties during the negotiations which took place both before and after the commencement of the stoppage of work. In the umpire's judgment, therefore, the continuance of the stoppage of work, owing to the disrepair of the mines, must be regarded as a continuance of the stoppage of work due to the coal dispute.

The Secretary to the Ministry of Labour has announced that a Board of Arbitration has been set up under the Industrial Courts Act, 1919, for the settlement of a dispute between the Shipbuilding Employers' Federation and the various shipbuilding trade unions covering riveters, platers, shipwrights, blacksmiths, &c. Sir William Mackenzie is chairman of the Board, the other members being Mr. James Fullerton, nominated by the employers, and Councillor G. J. Rowe, nominated by the workpeople. The dispute arose out of a proposal made by the Employers' Federation for the withdrawal of certain advances in wages which were granted during the war to men employed on the building of "standard" ships, and which were subsequently extended to men on merchant shipbuilding.

A meeting was held last week in London between shipbuilding employers and representatives of the Amalgamated Society of Woodworkers, in order to try to end the ship joiners' strike, which commenced on December 1 of last year. No agreement was arrived at, the employers refusing to depart from their original terms, namely, a 12*s.* reduction: 6*s*, now, 3*s.* in September, and 3*s.* in October.

The Shipbuilding Employers' Federation held a meeting in Edinburgh last Wednesday to consider the situation, and at the close of the meeting the following statement was issued: "The meeting of the Federation was held to report to members the position in the industry, especially in view of the fact that the agreement made between the Shipbuilding Federation and the executive council of the Joiners' Society, in order to end the strike, had not been confirmed by a vote of the shipyard joiners. Therefore the strike continues. The industry was in such a condition that the employers could not make any fresh offer. Unfortunately, work in most of the districts was coming to an end."

We read in *The Iron Age*, New York, that wage reductions, effective as from August 1, or shortly thereafter, have been planned in nearly every shipbuilding district between Maine and Texas. The plan includes complete re-classification of labour, and adjustment of wage scales according to ability. The cut will affect both piece-work rates and hourly rates, for it is pointed out that except for a 10 per cent. cut in March, the war-time rates have been maintained. It is expected that the Delaware River district will be first affected, arrangements having already been made for the new scale to be put into effect on the 1st inst. by the New York Shipbuilding Corporation, the Merchant Shipbuilding Corporation and the Sun Shipbuilding Company. It is stated that a still further cut may be required if the new scale fails to reduce construction costs enough to meet competition.

The same journal also states that the Fore River Works, Quincy (Mass.), Bethlehem Shipbuilding Corporation, is to cut its working force one-third, bringing it down to approximately 5,000. A reduction in wages, amounting to 15 per cent., was applied as from July 15.

The correspondent in Germany of the Federation of British Industries states that exports of iron and iron ware from Germany for the first nine months of 1920 amounted to 1,229,600 tons, as compared with 4,392,900 tons for the same period in 1913; those of machines fell from 418,400 tons in 1913 to 268,000 tons in 1920; exports of electro-technical products fell to about half the pre-war figure, while those of textiles fell even below that. Official export statistics for October and November, 1920 (the latest available) show for the most part a considerably higher figure than the average of the preceding months. For instance, exports of iron and iron ware in November amounted to 176,510 tons, as against 136,600 tons for the monthly average in 1920; vehicles were 28,810 tons, as compared with 14,510 tons; whilst exports of glass and glass ware had increased to 15,820 tons, or nearly twice the average for the earlier months of 1920. These figures indicate the rapidity with which German industries are recovering from the effects of war conditions, a recovery which is confirmed by the optimism of the directors of large machine works and by the high dividends they are paying. A number of examples are quoted by the correspondent in the Bulletin of the Federation for July 26.

It is reported that the National Seamen and Firemen's Union has decided to withdraw from the National Transport Workers' Federation, and has given notice to the effect that the union's affiliation to the Federation will cease at the end of three months. The reason put forward for this step is that at the annual conference of the Federation, held in Edinburgh in June last, a resolution was passed which would make it impossible for the union to continue its affiliation, the union contending that the said resolution gave the Federation full power to call out on strike any constituent union without any reference to a ballot or other authorisation. The Seamen and Firemen's Union, it is added, has always jealously guarded its right to control its own members and to act only on the result of a ballot. The union has 75,000 members.

NOTES ON NEW BOOKS.

Statistics relating to electricity supply over a number of years (Board of Trade units sold, capacity of plant, load, &c.) are contained in the "*Manual of Electrical Undertakings*," for 1920–21, vol. xxiv, which is compiled under the direction of Mr. Emile Garcke, and is published at the price of 30*s.* net by Messrs. Simpkin, Marshall, Hamilton, Kent and Co., Limited, Stationers' Hall-court, E.C. The book also deals with the electricity supply bills, special orders, &c. Separate chapters cover the work of the Water Power Resources Committee, and the Water Power Development in Canada. The directory portion deals with the Government Departments connected with the electrical industry; associations, institutions and societies, followed by particulars of the undertakings for electric supply and traction, for telegraph and telephone, manufacturing and miscellaneous, and Colonial electrical undertakings—all arranged alphabetically. The information comprises the date when the undertaking was registered, the system, the names of the officials, capital and last balance-sheet. Then are given a directory of officials, of lighting and tramway committees and of electrical contractors, the two latter according to towns arranged in alphabetical order. The present edition maintains the high standard of the preceding ones.

International motor car traffic is developing with such rapidity, especially between this country, France and Belgium, that a portable motor dictionary in English-French and French-English will be found of assistance. Although a tourist may know the language of the country in which he happens to be travelling, it very frequently occurs that on the spur of the moment, when pressed for a term he fails to remember it, although he may have used it hundreds of times. A dictionary which will help him in this eventuality is "*Henslowe's Motor Dictionary*," compiled by Mr. Leonard Henslowe, and published at the price of 4*s.* 6*d.* net, by Messrs. Constable and Co., Limited. It also gives tables of British and metric units, and a few useful phrases in English with the French translations.

The names of colliery owners, collieries, managers, fitters, associations connected with the coal trade, inspectors of mines, are given in "*Reid's Handy Colliery Guide*," for Northumberland, Durham, Yorkshire, Cumberland and Westmorland, published at 3*s.* 6*d.* by Messrs. Andrew Reid and Co., Limited, Newcastle-on-Tyne. It contains also the Explosives Act, Coal Mines Act, the rules concerning the use of electricity in mines, Workmen's Compensation Act, &c., and maps of the counties dealt with, showing the collieries and the railways serving the districts.

The advantages of co-ordinating knowledge are admirably illustrated by the "*Engineering Index*"

which is issued by the American Society of Mechanical Engineers. Excellent and comprehensive as many technical journals are, none can cover the whole field even of a single branch of engineering, and the endeavour made in this volume to bring together sufficient data to enable one to lay one's hand on information contained in some 700 engineering and technical publications is altogether praiseworthy. As is well known, the work was in existence before it was published by the American Society of Mechanical Engineers. It now forms a feature of the monthly journal of that society, and this matter is republished subsequently in the form of an annual volume at the price of 6 dols. It may be obtained from the offices of the Society, at 29, West Thirty-Ninth-street, New York. The present volume refers to about 12,000 items, and covers the leading American, British and Continental journals, and the work is, as usual, very well done.

The eighth edition, for the current year, of "*Liverpool Shipping Who's Who*," which is published at the price of 2*s.* by *The Journal of Commerce*, Liverpool, gives very complete information on the port, shipping companies, agencies, societies, associations, &c. Detailed tables deal with the various docks in Liverpool, and a special chapter covers the shipping facilities of Manchester. The various docks are shown in plans.

An official classified directory of members of "*The British Engineers' Association*," 32, Victoria-street, Westminster, S.W. 1, has recently been issued. It forms at the same time a very complete and very handy buyers' guide, in that it gives at the same time alphabetical lists of numerous mechanical specialities and other products, with the names of the manufacturers. The book should prove helpful in increasing our trade.

QUEENSLAND GOVERNMENT AND MINERALS.—To a large extent the Government of Queensland controls the mineral resources of the State. It owns, for instance, iron and steel works as well as mines. To provide additional ore for these the Government, looking beyond its borders, has recently purchased the mineral rights of Cockatoo Island, Zampi Sound, Western Australia. The deposit of iron ore there is considered to be one of the richest and best in the world. Analyses of samples from bore holes averaged 69·6 per cent. of metallic iron with 0·1 per cent. of silica and phosphorus, and 0·005 per cent. of sulphur. The ore from this source will be blended with another kind averaging 50 per cent. to 57 per cent. of iron but richer in silica.

EXPORT PRICES OF SWEDISH IRON.—The Ironworks Association, on June 29, agreed upon the following quotations for iron, we learn from *Swedish Export*. The prices are per English ton f.o.b. export port, in pounds sterling and American dollars (calculated on an exchange rate of 16·87 and 4·49 respectively):—

	£	*s.*	*d.*	Dols.
Export pig-iron (not over 0·015 per cent. of sulphur, 0·025 per cent. of phosphorus)	10	4	9	38·47
	10	10	10	39·60
Billets	25	11	11	96·17
	31	12	5	118·80
Rolled wire	28	12	2	107·48
	34	12	7	130·11
Rolled soft open-hearth steel, basic price	17	3	4	64·49
	18	7	5	69·02
Rolled Lancashire iron, basic price	22	11	8	84·86

PULLMAN CARS FOR THE LONDON, BRIGHTON AND SOUTH COAST RAILWAY.—The third-class Pullman service on the London, Brighton and South Coast Railway has proved so popular that it is to be enlarged by the addition of six new vehicles. Orders for these were placed with Messrs. Clayton Wagons, Limited, Abbey Works, Lincoln, and are now in course of delivery. In these new cars the standard Pullman construction has been departed from to the extent that steel underframes are used with separate bodies, while the bogies are of lighter construction than usual in the endeavour to reduce the tare weight as much as possible. The length over vestibules is 58 ft. 6 in. and over buffers 61 ft. The extreme width is 8 ft. 7 in. The bogies have a wheel base of 9 ft. and are centred 41 ft. apart; the tare weight is 32 tons 8 cwt. The bodies are of teak and pitch pine, the side panelling being of match-boarding. The bogies have laminated springs with auxiliary rubber springs above the axle boxes and coil springs for the bolsters. The two central compartments accommodate, together, 47 passengers. Each passenger is provided with a separate tip-up seat. The upholstery is Duratex leather. Removable tables with glass tops are placed between facing seats. The interior finish is in mahogany with dead white ceilings. The floors are covered with linoleum and carpeted. A kitchen and pantry compartment, 10 ft. 7 in. long, is placed at one end of the car, equipped with ice chest, range, &c., and all necessaries for the provision of meals and refreshments. At the opposite end of the car is a well-fitted toilet compartment. The floors of the latter and of the kitchen, &c., are laid with "Decolite."

FATAL DRYING CYLINDER EXPLOSION.

ON January 12 last a serious explosion of a drying cylinder occurred at Messrs. Thomas McLaren and Sons, linen manufacturers, Parkhead Power Loom Factory, Kirkcaldy. One man was killed, while two others suffered from shock and injury. A preliminary inquiry on behalf of the Board of Trade into the cause and circumstances of this explosion has been conducted by Mr. D. G. Guthrie, surveyor, and his report thereon has just been issued. From this report we have obtained the following information.

The cylinder was used for preparing and drying yarn prior to being woven into linen. It revolved at various speeds, the maximum being about 2 r.p.m. Steam was admitted at one end through a trunnion, and the water of condensation was picked up by pockets soldered to the shell, from which tubes were led to a central container, and through a trunnion in the other end of the cylinder, thence to a steam trap. The cylinder was 5 ft. in diameter and 5 ft. 6¾ in. in length overall. The shell was of sheet copper 0·057 in. thick, there being three longitudinal butt joints, with single straps brazed on the inside of the shell. The ends were of mild steel plating, 0·199 in. in thickness, and were flanged outwards and jointed to the shell by means of 20 copper rivets, ¾ in. in diameter. The joints were made tight and further secured by means of soft solder. The end plates were supported by three iron stays, ¾ in. in diameter, with forged collars abutting on the end plates; the ends of the stays were screwed with ¾ in. Whitworth threads and passed through the end plates and trunnion castings, to which they were secured by nuts on the outside; there were also six plain iron stays, ¾ in. in diameter, screwed Whitworth threads, passing through the plates with nuts on each side.

The shell was stiffened about mid-length by two light stiffeners of tee bulb section, soldered to the shell, made of tinned iron sheet and iron rod of ¼ in. diameter. A manhole, 11¼ in. by 15 in., was cut in one end plate, a suitable door being fitted. Two spring-loaded atmospheric valves, 1¼ in. diameter, were fitted to each end plate to admit air when the pressure in the cylinder was lower than that of the atmosphere. A pressure gauge was fitted to the steam inlet pipe.

The name of the maker and age of the cylinder could not be ascertained, but it would appear to have been at least thirty years old. The dressing machine, with the cylinder, was purchased by Messrs. McLaren in December, 1915. The cylinder was repaired on March, 1920, by Mr. Blyth, plumber, Kirkcaldy, the ends being removed, re-riveted and re-soldered, some slight leaks having developed. This was the only repair carried out while the cylinder was in Messrs. McLaren's possession.

The cylinder was not insured, but it was under external observation daily, and was examined internally at intervals of three to six months by the foreman mechanic. No record of such inspections was kept, but it was stated that the last internal inspection was in December, 1920.

When the explosion occurred both ends of the cylinder were blown out, the light cast-iron framework of the dressing machine being completely wrecked. Steam and water escaped, there being a large quantity of the latter; and one cylinder end was found 20 ft. away. The other end crushed two of the employees against the adjoining machine, with fatal results in one case.

The explosion appears to have been due to steam being admitted to the cylinder and setting up violent agitation in the water it contained, which, acting in conjunction with the weight of the water and the steam pressure, that was unduly high, having regard to the strength of the cylinder, caused the fracture of the stays, the bulging of the ends, and the parting of the ends from the shell.

In his "general remarks" Mr. Guthrie states that the cylinder was supplied with steam from the factory boiler, which was fitted with safety valves adjusted to blow-off at 100 lb. per square inch. A steam pipe, 2 in. in diameter, led from the boiler to a reducing valve, in the dressing machine room, 290 ft. distant. The reducing valve was regulated by a lever and weight arrangement, the reduced pressure being from 15 lb. to 20 lb. per square inch, depending upon the number of machines using reduced steam. Nine feet further on was a water separator drained through a steam trap into a tank. A spring-loaded safety valve in connection with the water separator was found to blow-off at 21 lb. per square inch, and a lever and weight safety valve on the steam trap opened at 23 lb. per square inch. When the reducing valve was rendered inoperative the pressure accumulated to 25 lb. per square inch, no steam being taken from the low-pressure side of the reducing valve other than that blowing-off at both of the safety valves.

The inlet valve chest was found, after the explosion, in the *debris* of the machine with its cast-iron wheel broken, the valve standing full open. A piece of packing was found in the cylinder drain tube, which reduced the effective sectional opening by about two-thirds. The presumption is, Mr. Guthrie states, that on the day previous to the explosion the packing had been picked up by the water lifter and had worked its way into the drain pipe. From an experiment with another machine it was judged that normally the cylinder which failed would, after a day's work, contain water to a depth of about 15 in., and with the drain pipe partly blocked up, there would be more water in the cylinder when the steam was admitted. The conditions obtaining when the valve was opened and the cylinder revolved caused the explosion.

Messrs. McLaren had no written guarantee as to the working pressure from the firm from whom the cylinder was bought, but considered that 10 lb. per square inch was the maximum pressure that could be safely used. The reducing valve was set to 20 lb. per square inch because it was found in practice difficult to get enough heat on the cylinders when all machines were running simultaneously, and 10 lb. on the pressure gauge of any given machine, which was sometimes required, could not always be obtained. It is thought, notwithstanding the good condition of the cylinder and the excellence of the workmanship, that 10 lb. per square inch was a higher working pressure than should have been used.

Mr. Guthrie concludes his report by stating that Messrs. McLaren propose to replace the machine by one of a more modern type, having cylinders made in accordance with present-day practice. Safety valves have now been fitted to the inlet pipes of the firm's other machines; the lever and weight reducing valve has been replaced by a spring-loaded one, not easily tampered with, and guaranteed to give a better supply of reduced steam, and the steam pipe from the boiler is to be covered with heat-insulating composition.

Mr. Carlton, the Chief Engineer Surveyor to the Board of Trade, makes the following observations in reference to the surveyor's report:—

"It is difficult to affirm with certainty the direct cause of the explosion, but it is evident that the cylinder was heavily loaded with a large quantity of water, and that in addition to the shocks set up by disturbances in the water due to the rotation of the cylinder and the sudden opening up of steam it was also subjected to a considerable internal steam pressure. These conditions were largely brought about by an obstruction to the water drain through a piece of packing carried into the cylinder probably from the steam passages, and the desirability of grids or strainers being fitted near to the steam trunnions is worth consideration.

"Plant of the nature of this cylinder is frequently arranged to draw from steam, through more or less restricted passages, at a higher pressure than that at which the plant itself is intended to work. It would lead to safe working and less condensation if steam pipes and passages were increased in size, so that reducing valves could be arranged to deliver steam at lower pressures more in keeping with the strength of the cylinders than is generally the case.

"The owners of the cylinder purpose to fit safety valves to the inlet pipes, which will have effect in regulating the pressure of the steam before entering the cylinders, but the loaded pressure on the safety valves should not exceed the safe working pressure of the cylinders, and they should be of ample size. In the absence of any such appliances in the present case, there were no means of exactly estimating the pressure under which the cylinder was worked.

"Unfortunately one man was killed, and two others were injured by the explosion."

PHILADELPHIA TRADE IMPROVEMENT.—We read in *Commercial America* that the total value of the port of Philadelphia's imports and exports during the year 1920 reflects the continued growth of the city's foreign trade. The import values totalled 282,157,831 dols., the exports 451,043,216 dols., indicating a total business of 733,201,047 dols., the greatest in the history of the port. In 1919 the import and export values amounted to 676,265,606 dols.—the imports, 153,874,515 dols.; exports, 522,391,091 dols. During 1920 a total of 4,129 vessels in the coastwise and foreign trades arrived. The clearances were 4,221 ships; a total of 8,350. This exceeded the number of the previous year by 1,347 vessels. In 1919, 3,504 vessels arrived and 3,499 departed, a total of 7,003. A sufficient amount of ship tonnage arrived and cleared the port in 1920 to move approximately 42,000,000 deadweight tons.

RECIPROCITY IN THE NEW UNITED STATES TARIFF.—The Tariff Bill now under consideration by the Congress of the United States, says *Commercial America*, confers upon the President wide powers in the matter of securing reciprocal trade and regulating the commerce of the United States with foreign countries and their colonies and dependencies. Section 303 of the Bill gives the President authority to grant lower rates on the products of such countries as grant like concessions to the products of the United States. It provides that the President may, at any time within three years after the passage of the Act, enter into an agreement for a period not exceeding five years with any country providing for a reduction not exceeding 20 per cent. in the duties on imports from such countries, in return for concessions granted to products of the United States when imported into such country. Section 302 gives the President authority to impose retaliatory duties on the products of countries which discriminate by tariffs or administrative practices against the trade of the United States. It provides that whenever the President is satisfied that a foreign country imposes duties or other exactions, limitations or embargoes upon products of the United States that are higher, unequal or unreasonable when compared with the duties in the United States, he is authorised and it shall be his duty to impose like restrictions on the products of such foreign country upon entry into the United States. In none of the more recent tariff laws of the United States have such wide powers been conferred upon the President as is proposed in the Tariff Bill now under consideration. He may put the reciprocal agreements referred to into effect, or he may impose the retaliatory duties provided for, by simple proclamation, without further action by Congress. Indirectly, the wide and final power which it is proposed to confer upon the President with respect to reciprocal and retaliatory measures will tend to give the tariff of the United States a greater flexibility than was possible under earlier laws.

THE AERODYNAMIC EXPERIMENTAL STATION AT GÖTTINGEN.

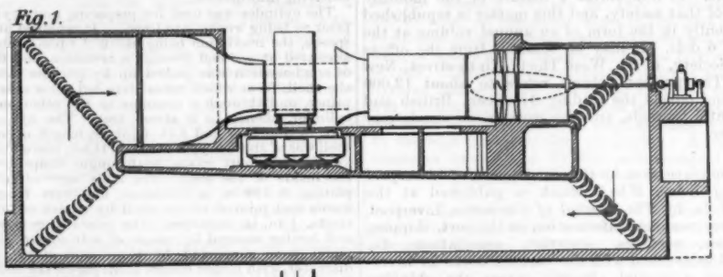
It may appear rather strange that the first aerodynamic institute in Germany should have arisen in the small University town of Göttingen, which is neither an industrial centre, nor a junction of flight routes; this, however, is characteristic of the mathematical nature of the science of aerodynamics. In 1897 the well-known mathematician Felix Klein, succeeded in establishing at Göttingen a Society for the Promotion of Applied Physics and Mathematics. He had as his colleagues, Waldemar Voight and E. Wiechert, teachers of physics and geophysics of wide renown, and when, in 1906, the Society for the Study of Aerial Navigation was founded, the first experimental aerodynamic station was, on Klein's suggestion, erected at Göttingen in 1907 under Dr. Ing. L. Prandtl. Good work was done at this small station, the enlargement of which, finally projected for 1914, was delayed by the war. Reports were published in the annual of the Society mentioned, and in the *Zeitschrift für Flugtechnik*; some extracts from the latter journal were reproduced in our columns in 1911. Prandtl's chief assistant, G. Fuhrmann, was killed early in the war. When late in 1916 the new buildings, to which the old station was subsequently transferred, were actually started, the dearth of copper, want of funds and depletion of the staff caused further delays. By 1919 the staff had been reduced to 15 persons, including a typist and a messenger, and the publication of reports was only resumed this year. The first new volume* of the "Ergebuisse der Aerodynamischen Versuchsanstalt zu Göttingen," contains a description of the new institute and articles on the theory and practice of the experiments with a report on some results. We now propose to describe the new experimental station.

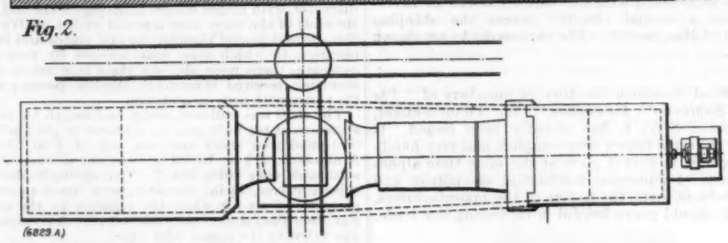
In its broad features, the new wind channel resembles the old one, which was the first of its kind. Before the details of the new installation were decided upon, descriptions had been published of the wind channel at Teddington (first described in 1910), on the lines of which the wind channel of the Massachusetts Institute of Technology was later constructed, and of Eiffel's Aerodynamic Laboratory at Auteuil in 1914, and experiments had been made at Göttingen on the advantages of the different types. The old Göttingen channel was a closed conduit, rectangular in cross-section and in plan, through which the air was circulated by a fan. The experimental chamber formed part of the conduit, and slots had to be provided, in special tests, for connecting the models inside with the instruments outside the conduit. In the 4-ft. square channel of the National Physical Laboratory air is drawn from the large room in which the channel is erected, through a honeycomb into the mouth of a trumpet, and delivered through a second honeycomb to the fan and back into the room, the working portion in the centre of the channel being accessible through a door in the side. Broadly speaking the more recent 7-ft. channels and the duplex 7-ft. channel of the National Physical Laboratory are of the same construction. In the Eiffel channel the air is also drawn from the room into the mouth of a trumpet; it is then delivered through a honeycomb as a free jet, circular in cross-section, across the experimental chamber, into the mouth of another trumpet and cone of greater length; the working chamber is itself a fairly large room, which is kept hermetically sealed.

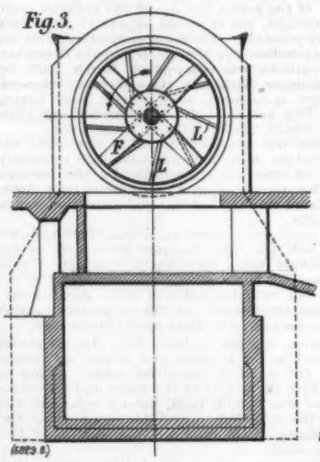
For his new plant Prandtl adopted the free jet, but not the sealed chamber; he adhered to his conduit, and provided an open working space between the nozzle delivering the air and the trumpet receiving it. The arrangement will be understood from the longitudinal section and plan, Figs. 1 and 2. The old channel was all disposed in a horizontal plane. In the new channel the disposition is vertical, there being an upper channel, interrupted by the experimental gap, on the ground floor of the building, a lower channel in the basement, and vertical connecting trunks. The cross-section of the conduit is not uniform throughout. The fan diameter is 3 m. (10 ft.); in the rectangular portion behind it the cross-section is 3 m. by 3·5 m., widening in the lower limb to 3·5 m. by 4·5 m. Just in front of the nozzle, the cross-section is 4·5 m. by 4·5 m. (15 ft. square), while in the nozzle itself the cross-section is reduced from 20 sq. m. to 4 sq. m. (215 sq. ft. to 43 sq. ft.), and to a diameter of 2·24 m. (7 ft. 3½ in.). The velocity of the air current through the nozzle is thus increased about five-fold, and the kinetic energy 25-fold. Thus the air receives $\frac{24}{25}$ of its kinetic energy from the pressure gradient in the nozzle, and any fluctuations in the energy of the air, entering the nozzle, will have little effect on the air leaving the nozzle. The conditions are not so favourable as regards the uniformity of motion in the direction at right angles to the longitudinal axis of the channel; equalisation in this respect is obtained by the aid of the peculiar louvres at the four corners of the conduits and of other devices. The whole nozzle can be adjusted both vertically and horizontally, which is desirable for accurate measurements.

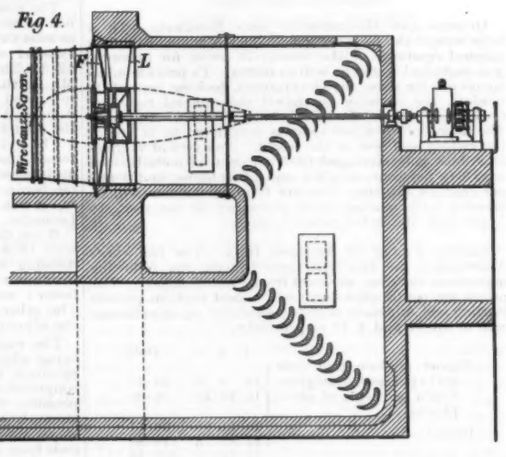
The building, 34 m. by 12 m., 7·6 m. high (112 ft. by 39 ft. by 25 ft.), is constructed of ferro-concrete. The models to be tested, and the instruments, are brought up on rails or moved by a 4-ton crane. There are two turn-tables as shown in Fig. 2, and of these the one between the nozzle and trumpet can be lowered, so that the instruments can be rested firmly on specially prepared beds. There are also four water tanks (Fig. 1) supporting floats which carry a frame; this frame can bear a load of 2 tons, and by its aid a model, after having been centred horizontally, can be turned about its vertical axis. This mode of mounting has proved particularly serviceable for testing propellers; the whole gearing with the 50-h.p. motor can be floated for thrust measurements without requiring any longitudinal adjustable coupling. So far measurements have been made by a three-component balance, the six-component balance not being completed. The fan supplies air at a velocity of 52 m. per second (171 ft.), which can be raised temporarily to 60 m.; the usual speed is 30 m. (nearly 100 ft.). The length of a long climb of the conduit, which is built in ferro concrete, is 27·5 m. (90 ft.). The models are made of plaster, covered with a galvanic coating of copper and are reproduced by galvanoplastic methods; wood is not much used. Wing models are also formed in plaster round cores of sheet iron, stiffened if necessary. Models do not usually exceed 1·5 m. (5 ft.) in length and the average weight ranges from 5 kg. to 8 kg.: 25 kg. is the maximum weight.

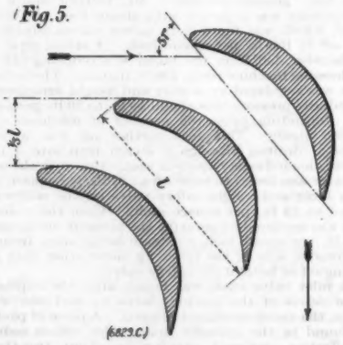
Electric current is supplied to the works at 5,000 volts three-phase and the wind channel is operated by a Ward-Leonard motor-generator set. The fan (Figs. 3 and 4) is helical and has four





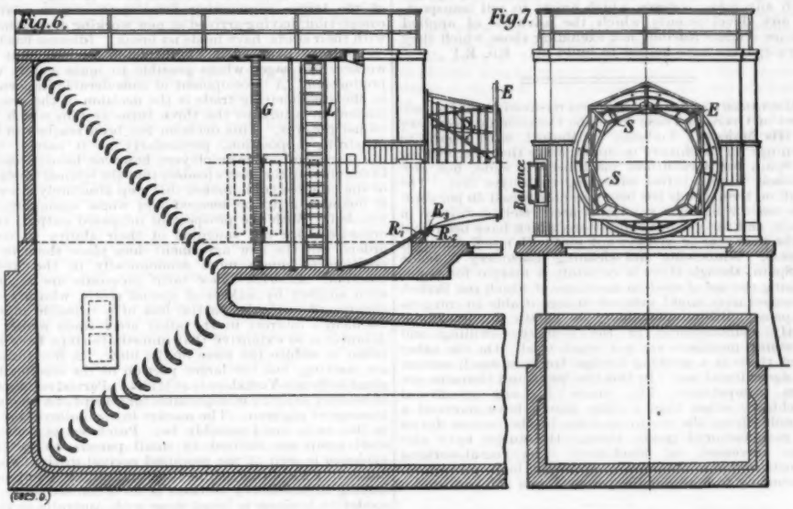


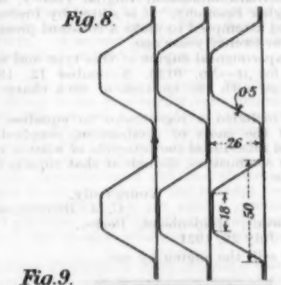


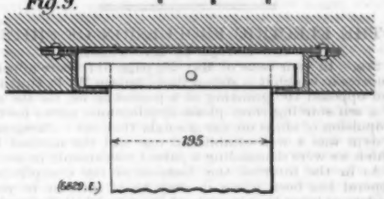


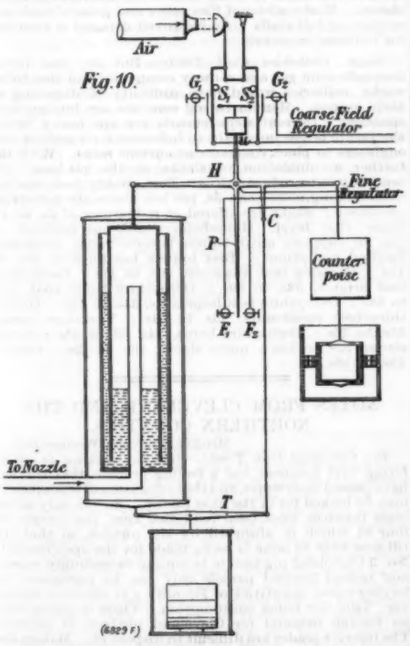
* Edited by Professor L. Prandtl, assisted by Dr. C. Wieselsberger and Dr. A. Betz. Munich and Berlin: A. Oldenbourg. 140 pages, small quarto, with many diagrams. [Price 40 marks.

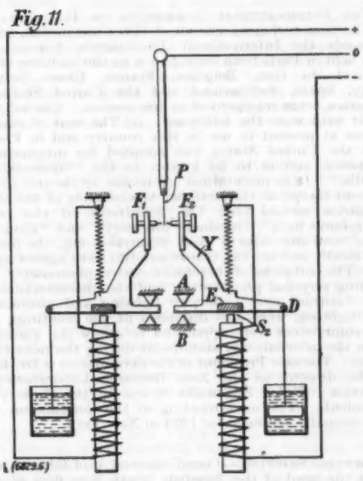
blades F of wood, 3 m. in diameter; the pitch is 2 m. and the steel hub has a diameter of 1·2 m. Immediately behind the blades are mounted nine guide vanes L; in front of the fan are wire-gauze screens (wire diameter 2 mm., 45 mm. mesh). The motor-generator set just mentioned consists of four machines (Siemens-Schuckert) on one shaft, viz., an asynchronous motor of 315 kw., 5,200 volts, 50 periods and 900 r.p.m.; a direct-current dynamo with inter-poles, compound wound, of from 0 to 250 kw. and 0 volts to 440 volts, generating current for the fan motor; and two smaller generators for the excitation of the fields. The fan motor can











be run at speeds ranging from 30 r.p.m. up to 1,000 r.p.m.; the method of speed regulation will be referred to later. The air stream leaving the guide vanes of the fan, enters the conduit and is four times deflected at right angles by the louvres at the four corners. These louvres are made of ferro-concrete and are sheathed with sheet iron at their sharp angles; they are let into the walls of the conduit, and fixed with concrete. The louvres at the first two corners deflect the current without changing the cross-section; at the other two corners the section widens. In the former case the angle between the air current and the chord of the vane is 48 deg., in the latter case 51 deg. (Fig. 5); the length l is 600 mm. (2 ft.) at the first three corners, and 400 mm. (15¾ in.) at the fourth. Before entering the nozzle the air passes through the equalisers G (Figs 6 and 7). These consist of strips of sheet iron, 19·5 cm. (7¾ in.) deep, 0·5 mm. thick, alternately plane or bent into the form of troughs, and riveted together and suspended as indicated in Figs. 8 and 9; the plane strips are 26 cm. (10 in.) apart. The ladder L shown in Fig. 6 serves for fixing perforated screens for the further elimination of turbulence from the air current. As the air is kept in circulation in the conduit the energy required to maintain the high-speed air flow is only about two-thirds of the initial value, and the losses by friction at the corners, &c., are not large; the experimental figures, however, are not given.

The nozzle shown in Figs. 6 and 7 happened to be available; a longer nozzle would have been preferable, but space had also to be economised. The outer end, originally cylindrical, has been made slightly conical by inserting laths under the inner lining of sheet metal. The main body of the nozzle, including the portion in which the square section changes into a circular section, is built in Monier concrete; this part ends in the cast-iron ring R_1 to which the second ring R_2 is bolted. The outer exchangeable nozzle is attached to R_2; it is built up of wood as shown in Fig. 7 so as to form a polygon of 16 sides, stiffened by the iron frame E and the iron rods S, which can be slightly shortened or lengthened in order to make the nozzle axis exactly horizontal; the wooden ring R_3 moves in this adjustment together with R_2. It will be seen from Fig. 1 that the air stream, after leaving the nozzle and crossing the experimental gap, enters a considerably wider trumpet, the two cross-sections being 4-sq. m. and 8·8 sq. m. (44 sq. ft. and 95 sq. ft.) respectively. This widening was necessary to avoid large energy losses in the conversion of velocity into pressure which takes place in the trumpet. A hole (not shown in the diagrams) has been provided in the trumpet to let the excess air escape.

In conducting measurements the machinery is controlled with the object of keeping constant not the air velocity, but the kinetic pressure $\frac{1}{2}\rho v^2$ (where ρ is the density and v the velocity of the air). The air resistance will, in general, be proportional to this pressure, and when the pressure is kept constant, the velocity will vary with the barometric pressure and the temperature of the air which rises during the experiments. The pressure constancy is obtained with the aid of the apparatus illustrated in Figs. 10 and 11. A bell suspended from the beam H dips into toluene. The space in the bell, above the toluene, communicates with the interior of the nozzle, and the buoyancy due to the air pressure is balanced by weights suspended from T (not directly from H). When the kinetic pressure changes, the pointer P will be deflected and will make contact either with F_1 or with F_2; these contacts are connected to the field circuit of the dynamo supplying the fan motor, the control mechanism of which comprises a coarse and a fine regulation, operating in 88 steps; F_1 and F_2 are in the circuit for the final adjustment, G_1 and G_2 in the coarse adjustment. To avoid oscillations, the contacts F_1 and F_2 are interrupted a little before the equilibrium pressure is attained; this is effected with the aid of additional devices shown in Fig. 11. F_2 (and similarly F_1) is a Y-shaped lever, suspended by a spring, connected to a dashpot at D, and oscillating between the stops A and B under the action of the solenoid S_2, which has its iron armature E on the Y lever. The end of P is flexible. When P is deflected to the right, touching F_2, S_2 is energised, E is attracted, and the whole part Y moves first downward (against the dash-pot action), until it is arrested by B; during this period the auxiliary motor changes the field resistance; then Y turns about B, contact F_2 is broken, Y jumps back to A and turns about A as pivot until P is again in the neutral position. Thus F_2 moves fast in a jerk away from P, and then approaches it more slowly.

The whole control is by push buttons. As regards the way in which the motor is automatically started or stopped, and the whole balance is set for any particular kinetic pressure, we must refer again to Fig. 10. When the beam H is strongly deflected, as it can be because the tip of P is flexible, the coarse adjustment contacts G_1, G_2 come into operation; here again the contact is interrupted before equilibrium is really reached to prevent hunting. The little air jet at the top of the diagram Fig. 10, blowing into a cup, also comes from the nozzle and this air jet counteracts the beam movement. The nozzle of the small jet can be so adjusted that, in starting the motor, contact G_1 is broken, as soon as a definite fraction of the pressure is attained; this fraction will be the greater, the higher the desired pressure. In order to adapt the sensibility of the device to the desired pressure, the balancing

weight is not attached directly to the beam H, but to the bar T which is connected to H at the point C; the weight *u* serves for adjusting the equilibrium.

The space at our disposal does not permit us to describe the three-component balance dealt with in the report, which also gives the results of experiments on over 100 different wing sections.

INTERNAL COMBUSTION ENGINE THEORY.

To the Editor of Engineering.

Sir,—In the report, on page 63 of your issue No. 2,897, dated July 8, of the discussion on Mr. Wimperis' paper on "Internal-Combustion Engine Theory, with Relation to Higher Economy," it is stated by Professor Low that he had attempted to make a constant-pressure cycle engine over twenty years ago.

I made an experimental engine of this type and took out a patent for it—No. 6133, November 12, 1902. The trouble was with the ignition of each charge of mixture.

The system included a regenerator to equalise the temperature of the gases of combustion, supplied to the engine—and introduced the principle of what is now called flameless combustion, though at that time it had no specific name.

Yours truly,
C. J. Reynolds.

39, The Crescent, Maidenhead, Berks.,
July 29, 1921.

P.S.—I have still the engine by me.

THE ELECTRIC PROPULSION OF SHIPS.

To the Editor of Engineering.

Sir,—In your issue of May 20, page 617, there appears a notice in which it is stated that Captain W. P. Durtnall had opposed the granting of a patent to us, for the use of a self-starting three-phase synchronous motor for the propulsion of ships on the grounds that his "Paragon" system was a well-established one and the method for which we were demanding a patent was already in use.

As in the interval the decision of the Comptroller-General has been given it may be of interest to your readers to learn that in spite of Captain W. P. Durtnall's opposition, a British Patent No. 133301 has been granted to us for the above-mentioned method.

Yours very truly,
Société Anonyme Brown, Boveri and Cie.

Baden, Switzerland, July 29, 1921.

RAILWAY AND ROAD TRANSPORT.

To the Editor of Engineering.

Sir,—Having read the articles "Canal Proposals" and "Railway and Road Transport," contained in the issues of Engineering April 15 and July 22, respectively, one feels somewhat diffident, as a road transport representative, in craving the hospitality of your columns.

The tone of these articles is so consistently unfriendly towards all forms of transport other than that of the railways, even the traders as a whole not escaping a share of castigation.

It apparently has escaped notice that the attitude of road transport, canal transport, coastwise shipping and the trading community towards the railway companies' desire for increased powers arises from some common cause. If after enjoying a practical monopoly of inland transport for fifty years the railways have failed by their general conduct to create an atmosphere of confidence in those around them the fault is their's, and does not rest with the community. Two railways at least have in the past received powers to develop road transport, and had they exercised these powers to the full might by now have been beyond the pale of road competition to a large extent.

It is impossible in a short letter to traverse many of the statements contained in the above articles which are open to criticism, such as that which suggests that the traders of this country are, so to speak, an official opposition to the railways—or that the road transport industry desires to see the railways bound up by stringent regulations whilst they themselves are to be free from practically all control, &c.

The main factor that is weighing with the community is that the railways are in the future to be guaranteed a sufficient income by the traders to encourage their financial support. A large section of the trading community does not consider the moment opportune for allowing the railways to launch into new activities, thereby possibly increasing their own financial obligations.

Further, in view of the experience of the past the additional power being placed in the hands of the railway companies, first by the elimination of competition against them, and secondly by financially guaranteeing their future, is an experiment which to many appears of sufficient magnitude for present requirements. Lastly, rightly or wrongly, other forms of transport believe they have reason to be apprehensive that they will be handicapped in obtaining a fair proportion of traffic in competition with the railways, bearing in mind that the trader will be responsible for any financial deficit which may occur in the railways' budgets.

In your issue of April 15, you state: "The railways themselves, we believe, are prepared to submit to some form of control, in return for facilities for road services. They have been regulated so long on the ground that they owned a monopoly that they are used to the general idea." The answer to that is contained in the admission of Mr. Watson, general manager of the Lancashire and Yorkshire Railway, that his company were running road services *ultra vires*, and intended to continue to do so.

Yours faithfully,
C. le M. Gosselin, Chairman, Commercial Motor Users' Association, North-Western Division.

Preston, July 30, 1921.

[Our correspondent has not quite correctly represented our attitude on the question he raises. We admit that it is true that we have never accorded other than very qualified support to proposals for the resuscitation of canal traffic, but we have always held that there is a very considerable future for mechanical road transport. Our point has been that in our opinion the railways, as common carriers, should have the right to avail themselves, equally with any other concern which exists to sell transport, of any developments which the advance of applied science renders feasible, not excluding those which they as ratepayers have helped to build up.—Ed. E.]

Machinery in Spain.—Reports received in the Department of Overseas Trade from the Commercial Secretary to His Majesty's Embassy at Madrid, with regard to openings for machinery in Spain, state that the opening in Spain for agricultural machinery is wide, but new business often involves educating the buyer first. The tariff on these goods has been recently raised 50 per cent. The tractor has not yet established itself definitely in Spain, and the various exhibitions which have been held in the past year or so have not met with much apparent success. Winnowing and cleaning machinery is made in Spain, though there is certainly a margin for popularising the use of modern machines of which the British manufacturers might take advantage if able to compete in price. Milling machinery is partly imported and partly manufactured in the country. Drilling and threshing machines are not much used. On the other hand there is a growing foreign trade in small motors for agricultural use. In this the Swiss and Germans are keen competitors. The trade in non-agricultural machinery other than mining should have received a stimulus from the recent increase in the import duties on manufactured goods, though the duties have also been increased on machinery. The metal-working industries have obtained a specially high protection, amounting to between 100 per cent. and 250 per cent.

The International Commission on Illumination.—The first technical session of this Commission, which succeeds the International Photometric Commission, was held in Paris from July 4 to 8, at the building of the Société du Gaz. Belgium, France, Great Britain, Italy, Spain, Switzerland and the United States of America, were represented at the session. The subjects dealt with were the following: (i) The unit of candle-power at present in use in this country and in France and the United States was adopted for international purposes, and is to be known as the "international candle." It is maintained by means of electric incandescent lamps at the national laboratories of the three countries named. (ii) The definitions of the terms "luminous flux," "luminous intensity," and "illumination," and the units of these quantities, viz., the lumen, the candle and the lux (metre-candle) were agreed upon. (iii) The subjects of heterochromatic photometry (including physical photometry, and the characteristics of the "normal eye"), factory lighting and automobile headlighting, were also discussed at the meetings, and sub-committees were appointed to study the questions from the international standpoint during the next three years. The new President of the Commission is Dr. E. P. Hyde, director of the Nela Research Laboratories of America; Major Edgcumbe is one of the three vice-presidents. The next meeting of the Commission was provisionally arranged for 1924 in New York.

Swedish Shipping.—Consul-General Axel Johnson, who is at the head of the Swedish North Star fleet of seagoing vessels, better known as the Johnson Line, takes a very pessimistic view of the situation for Swedish shipping, according to *Swedish Export*. During former periods of depression it has always been possible, he says, to square the accounts if with some difficulty, but at present it is not only impossible to make the earnings cover the expenditures, but also impossible to find employment for the vessels, even at rates that spell a clear loss to the owners. The shipowners, in consequence, have been compelled to lay up their vessels to a very large extent. This applies to the regular lines as well as to owners engaged in coast and tramp shipping. Of the Johnson fleet, which is entirely composed of liners, about 45 per cent. are idle at present. The low freight charges, following upon the low exchange for German money, have been the cause of depriving Swedish lines of a good deal of cargo, the low rates from Hamburg having tempted many, both exporters and importers, to have their goods shipped through Hamburg to the detriment of Swedish shipping. According to other estimates more than 75 per cent. of the entire Swedish tramp fleet is at present lying idle. The reason for this, is first of all, to be found in the unfavourable situation for Swedish timber shipment, in which carrying most of that class of Swedish tonnage is usually engaged. The protracted British coal strike had also been directly instrumental in bringing about this state of affairs, as it has entirely deprived the ships of any chances of obtaining the return freights which are absolutely necessary to the tramp owners in order to make the accounts balance with the present low freight rates.

NOTES FROM SOUTH YORKSHIRE.

Sheffield, Wednesday.

Municipal Waste.—Sheffield manufacturers' demand for municipal economy has aroused widespread controversy as to ways and means. The Chamber of Commerce points out that many of the largest manufacturing concerns, who are the principal contributors to the city's revenue, are only employed to the extent of one-third of their normal capacity, with no early prospect of improvement. Immediate action is called for to limit municipal expenditure to such a figure as will effect a drastic reduction in the rates "such as the manufacturing concerns can reasonably be expected to meet in these extraordinary times of depression."

Iron and Steel.—Suspension of manufacturing activities has not been general this August Bank Holiday. Several of the larger engineering firms with orders awaiting completion, having arrived at new working arrangements with their staffs, have made no break. Idleness has been compulsory over such a protracted period, that the workers are eager where possible to make a start with production. A development of considerable importance to the steel-melting trade is the decision of the crucible makers to return to the three turns system which prevailed pre-war. This decision has been reached in face of strong opposition, particularly as it carries with it a wages cut. The employers, however, have succeeded in convincing the men's leaders that the critical condition of the crucible trade makes this step absolutely essential if business is to be secured and worse unemployment avoided. With the prospect of increased output, trade organisers are not sanguine of their ability to tempt orders, but the new agreement does place them in the position to quote more economically in the world's markets. America's new tariff proposals are regarded with anxiety by makers of special steels, who are thus threatened with the partial loss of a valuable market. Sheffield's interest in the alloy steel trade across the Atlantic is so extensive that immediate steps have been taken to reduce the force of the blow. A few furnaces are melting, but the larger portion of the steel-making plant in South Yorkshire is still idle. Partial resumption of foundry activity is responsible for receipt of a moderate tonnage of pig-iron. The market in steel alloys is about as flat as it could possibly be. Purchases of iron and steel scrap are limited to small parcels. Very faint evidence is seen of the promised revival in the finished trades. Except in machine tools and railway equipment, buying in the heavy sections is on a limited scale. A moderate business is being done with Australia in sheep shears. Most makers of files, saws and joiners' tools are employing full staffs. An improved demand is reported for builders' ironwork.

South Yorkshire Coal Trade.—But for the lively demands from gas and railway companies and electricity works, collieries would have difficulty of disposing of their output. Manufacturing concerns are buying very sparingly. Current requirements are not heavy, while the future is too uncertain to influence steel-makers and engineers to place contracts at current rates. With the further accumulation of slacks at the pit-head, the tendency is to reduce prices. Best quality fuels are not commanding more than 3*s.* per ton above the pre-strike quotation; slacks are offered at reductions of 2*s.* to 4*s.* below that level. Householders are not inclined to buy in supplies until values become more stabilised. Revised quotations:—Best branch handpicked, 40*s.* to 41*s.*; Barnsley best Silkstone, 40*s.* to 41*s.*; Derbyshire best brights, 38*s.* to 39*s.*; Derbyshire house coal, 37*s.* to 38*s.*; Derbyshire best large nuts, 34*s.* to 35*s.*; Derbyshire best small nuts, 33*s.* to 34*s.*; Yorkshire hards, 35*s.* to 36*s.*; Derbyshire hards, 34*s.* 6*d.* to 35*s.*; rough slacks, 22*s.* to 24*s.*; nutty slacks, 20*s.* to 22*s.*; smalls, 15*s.* to 16*s.*

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

Middlesbrough, Wednesday.

The Cleveland Iron Trade.—Holiday-making is interfering with business, but a feeling prevails that matters have passed their worst, and that expansion of transactions may be looked for in the near future. As yet only seven blast furnaces have been rekindled here, the output of four of which is absorbed by the owners, so that up till now next to none is being made for the open market. No. 3 Cleveland pig-iron is becoming exceedingly scarce, and indeed limited parcels only can be purchased by buying equal quantities of Foundry 4 at the same figure, viz., 140*s.* for home consumption. There is practically no foreign demand for Cleveland pig-iron at present. The inferior grades are difficult to dispose of. Makers are keen to sell from their large stocks at 117*s.* 6*d.* for No. 4 forge and mottled, and 115*s.* for white iron.

Hematite Iron.—There is very little passing in East Coast hematite. Stocks are considerable, and buyers are disinclined to pay prices named. Nos. 1, 2 and 3 are 160*s.* for home consumption, and offers to sell for abroad at 140*s.* and even a trifle less, fail to tempt foreign customers.

Coke.—There is abundance of coke. Prices are coming down, but they are still much too high to meet the views of buyers. Foundry kind is about 42*s.* 6*d.* f.o.b., and blast-furnace quality is in the neighbourhood of 40*s.* delivered.

Foreign Ore.—There is absolutely no market for foreign ore, consumers having large contracts made and heavy stocks.

Manufactured Iron and Steel.—No new feature of moment is noticeable in manufactured iron and steel. Common iron bars are 16*l.*; marked bars, 20*l.*; steel

billets, 12*l.* 10*s.* to 13*l.*; steel boiler plates, 21*l.*; steel ship, bridge and tank plates, 15*l.*; steel angles and joists, 14*l.* 10*s.*; rounds and squares, 14*l.*; flats, 15*l.*; heavy steel rails, 14*l.*; fish plates and sleepers, 19*l.*; black sheets, 19*l.*; and galvanised corrugated sheets, 23*l.* 10*s.*

Shipments of Iron and Steel.—The Middlesbrough shipments of iron and steel during July reached only 10,200 tons, of which 5,240 tons were pig-iron, 1,499 tons manufactured iron, and 3,461 tons steel. Of the pig-iron shipped 2,035 tons went to foreign ports, and 3,205 tons to coastwise customers; of the manufactured iron despatched 435 tons went to foreign ports and 1,064 tons to coastwise customers; and of the steel loaded 578 tons went to foreign ports and 2,883 tons to coastwise customers. The principal customers were: Pig-iron—Belgium, 1,460 tons; France, 910 tons; Italy, 330 tons; manufactured iron—Straits Settlements, 591 tons; Holland, 296 tons; and steel—India, 897 tons; Natal, 560 tons; Cape Colony, 484 tons; and the Straits, 482 tons.

NOTES FROM THE NORTH.

GLASGOW, Wednesday.

Scottish Steel and Iron Trades.—In the iron and steel trades of Scotland there is still very little doing and production is on quite a small scale yet, as very few orders are being booked. Only a limited number of works have reopened up till now on account of the high price demanded for fuel, but as there is a falling tendency noticeable in the coal market, it may not be so very long now before there is a big increase in production of iron and steel. Everything of course depends on fuel, and as soon as that is offered on a reasonable basis the home manufacturers will be placed on such a footing as to be able to meet the very severe competition which the Continental makers have been putting up for some time. The German producers are now to the fore with material which they are enabled to deliver here at a very low price because of the favourable rate of exchange. Inquiries all round are far from encouraging this week, but some improvement is looked for in the near future.

Scottish Pig-Iron Trade.—There has been no change in the Scottish pig-iron trade since last report, and stocks on hand seem ample to meet the current demands. This is due to the fact that consumers are not heavy in their requirements at the present time, but when fuel gets cheaper business will open out and there will be a bit of a scramble for whatever iron is available. Both foundry and forge iron are somewhat scarce now. Furnaces in this area are still out of blast and there is little talk of them being relighted in the meantime. Prices are practically unaltered, but are the subject of negotiation when parcels ex-stock are wanted.

Malleable Iron Trade Wages Reduced.—Mr. John M. MacLeod, C.A., Glasgow, has made the following intimation to Messrs. James C. Bishop and Owen Coyle, joint secretaries of the Scottish Manufactured Irion Trade Conciliation and Arbitration Board: "In terms of the remit I have examined the employers' books for May and June, 1921, and I certify the average net selling price brought out is 19*l.* 12*s.* 4·4*d.*" This means a decrease in the wages of the workmen of 42½ per cent. on basis rates.

Scottish Shipbuilding.—The month of July, which is the holiday month generally throughout the Scottish shipbuilding areas, is seldom responsible for a very heavy tonnage of new vessels, and the past month has been no exception as the output only totalled 18 vessels of 38,788 tons, made up as follows:—

	Vessels.	Tons.
The Clyde	13	29,448
The Forth	1	3,520
The Tay	1	2,900
The Dee and Moray Firth ...	3	2,920
Total	18	38,788

The above figures are rather under the average output, but considering the present industrial depression they cannot be looked upon as other than fairly satisfactory on the whole. The Clyde return is poor in comparison with over 40,000 tons for June, and over 65,000 tons for July of last year. The total for the seven months of this year is now 131 vessels of 265,248 tons, as against 115 vessels of 352,262 tons for the corresponding period of last year, and 146 vessels of 377,270 tons for the same time during 1913. Last month, while the largest vessel launched was the geared-turbine steamer Huntsman, 8,950 tons, by Messrs. Charles Connell and Co., Scotstoun, for Messrs. T. and J. Harrison, Liverpool, undoubtedly the most outstanding vessel was the hopper dredger Gunga, 4,000 tons, launched by Messrs. William Simons and Co., Renfrew, for the Commissioners of the Port of Calcutta. She has been specially designed for work on the Hooghly River, and is quite the largest vessel of her kind ever built on the Clyde.

NOTES FROM THE SOUTH-WEST.

CARDIFF, Wednesday.

The Coal Trade.—The interruption of the August Bank Holiday brought business to an almost complete standstill, though work at the collieries was officially only suspended for a day. There was also a better return to work than is customary after a holiday, with the result that outputs are not likely to be much affected by the day's idleness. The idle pits of the Ebbw Vale Company, which have been stopped for four months, were also restarted on Tuesday, but it is not expected, that there will be much output for the next week or so as a considerable amount of repairing work will doubtless be necessary before coal-winding is begun in earnest. Operators have generally adopted a hold-off policy. Buyers in particular have been reluctant to order, except for immediate requirements, anticipating that a further fall in prices is likely to take place before the end of the month. It is reported that Argentine railways have placed contracts for 40,000 tons of Monmouthshire Black Vein coal at 30*s.* f.o.b., delivery between September and December in monthly quantities of 10,000 tons. The coal supplied is to consist of two-thirds large at 35*s.* per ton and one-third small at 20*s.*, while 14*s.* extra is to be allowed for freight. Colliery salesmen generally indicate 40*s.* and 20*s.* respectively for best large and small for delivery over the year, but buyers are not disposed to place business at these figures. Nominally round 42*s.* 6*d.* is the current price of best large and 25*s.* for best steam smalls, with ordinary smalls round 22*s.* 6*d.*, but the tendency is easier, especially for delivery in the second half of the month. There is little demand for dry coals, and though 42*s.* 6*d.* is asked for best large, good drys are obtainable at 40*s.*, with the inferior smalls down to 15*s.* Foreign exports in the past week at 235,000 tons have only been exceeded in two previous weeks of this year. Shipments from the port of Cardiff, at 170,000 tons, established a record for the year, as also did the exports to British coaling stations at 41,000 tons. A resumption of exports to South America was also made in the past week, when 31,000 tons were despatched to that country, while shipments to France at 76,000 tons also show improvement. In 1920, however, the past week's shipments were exceeded on many occasions. A significant step by colliery workmen is the decision of stokers and craftsmen, who just before the national stoppage became affiliated with the Miners' Federation, to revive their own association and once more become an independent body in the mining industry.

Iron and Steel Trades.—In view of the fact that costs of production are generally reaching a lower level a more optimistic feeling prevails in the Welsh tin-plate trade. There has been a broadening in the inquiry both from at home and abroad, while the price of sheet and tin bars has been reduced another 1*l.* to 9*l.* 10*s.* per ton. Coal supplies are also coming to hand and more mills have been restarted. Stocks of tin-plates are nearly exhausted, and some steady buying would quickly put half the mills in operation. Standard boxes are quoted at 23*s.* 6*d.* to 28*s.* for prompt delivery, while forward business has been concluded at 23*s.* 6*d.*

JAROSITE IN VICTORIA, AUSTRALIA.—The existence of well-defined seams of jarosite in the cliffs near Anglesea, Victoria, is referred to in the *Chemical Engineering and Mining Review*, Melbourne. This little-known mineral is described as a basic sulphate of iron and potassium, and in composition corresponds to its better-known sister mineral, alunite, which is a basic sulphate of aluminium and potassium. Jarosite may be described as alunite in which iron has taken the place of aluminium.

THE BRUSH ELECTRICAL ENGINEERING COMPANY, LIMITED, LOUGHBOROUGH.—This company state that on Saturday night last one of their timber sheds containing a valuable stock of seasoning timber for rolling-stock manufacture caught fire, possibly by a spark from a passing train. In a few moments the whole shed was completely destroyed, together with some log-converting machines. The works' brigade and the town's brigade, with the assistance of the works' staff and workmen, were very quickly on the spot, and succeeded in limiting the effects of the fire to the shed in question. The company's manufacturing operations are not curtailed in the least, nor will any unemployment be caused. The large stock of cars, omnibuses and similar work in process of manufacture is unharmed. The engineering section, which is further away from the scene of the fire, is intact.

CONVERSION OF THE VESSEL "CARGO SHIPPER."—The Newcastle Engineering Company, Limited, ship-repairers and engineers, Tyne Dock Entrance, South Shields, have recently transformed the vessel Cargo Shipper. Originally a three-masted auxiliary schooner, the vessel, which measured 136 ft. by 24·5 ft. by 11·2 ft., and is owned by Cargo Carriers, Limited, has been reclassed and converted into a full-powered motor ship. The original engines were entirely removed and new seatings constructed. The new propelling machinery consists of a 152-b.h.p. Vickers-Petter oil engine, directly reversible, of the latest type. The auxiliary machinery is a Reavell air compressor, capable of compressing air to 200 lb. per square inch, and a general service pump. The auxiliary machinery is driven by a small Petter oil engine, and is entirely self-contained. The engine-room is placed right aft, and the extreme length occupied between bulkheads is only 17 ft. 11 in. In the engine-room are placed fuel oil storage tanks, air receivers, oil filters, &c. The main and auxiliary engines have been supervised by the Bureau Veritas International Registry of Shipping during construction and installation. Hamworthy motor winches are fitted to all hatchways, so that it is possible to discharge the cargo of 460 tons in a period of 24 hours. Top masts, bowsprit and top sails have been dispensed with, but the original lower sails have been retained for service during the heavy winter winds round the coasts. With fuel oil at its present price of 6*l.* per ton, the cost of running the engine for 24 hours at full speed is 5*l.* 4*s.* 6*d.* Presuming an average speed of 7 knots, port to port—this speed was attained against a 2-knot tide coming up the Tyne—the cost in fuel oil works out at 0·016*d.* per ton-mile. On the trial trip the vessel, laden with about 320 tons, the speed averaged 8·15 knots over the measured mile.

NOTICE OF MEETING.

THE NORTH OF ENGLAND INSTITUTE OF MINING AND MECHANICAL ENGINEERS.—Saturday, August 6, at 2 p.m., in the Wood Memorial Hall, Newcastle-upon-Tyne, Election of Representatives on the Council of the Institution of Mining Engineers; Vote of Thanks to Mr. M. W. Parrington, retiring Honorary Secretary. The following paper will be read or taken as read: "The Carbonisation of Coal at Low Temperatures," by Mr. John Roberts, D.I.C. The retiring president (Lieutenant-Colonel F. R. Simpson) will deliver an address.

LAUNCH AT HALIFAX SHIPYARDS.—The ss. Canadian Cruiser, 10,500 tons d.w., was successfully launched at the Halifax shipyards on July 9, according to *Iron and Steel*, of Canada. The Canadian Cruiser, which is the largest vessel built in Canada for ocean-going purposes, is 445 ft. long, 56 ft. beam, 38 ft. depth and has a draft of 29 ft. A second vessel, of similar dimensions, will be launched in the Autumn.

TRAFFIC ON THE UNITED STATES RAILWAYS.—According to the *Engineering News-Record*, New York, the total tonnage of commodities transported over the Class 1 railroads of the country during the year ended December 31, 1920, was 2,249,567,625 tons. Of that tonnage 53·60 per cent. was made up of the products of mines; manufactured and miscellaneous articles comprised 21·91 per cent. of the tonnage carried; agricultural products, 9·78 per cent.; products of forests, 8·74 per cent.; all "less-than-carload freight," 3·98 per cent.; and animal products, 1·99 per cent.

SMOKE DETECTING FIRE ALARM.—Our attention has recently been called to a new form of fire alarm which depends for its action on the presence of smoke and is not affected by temperature changes on which reliance is usually placed for operating fire alarms. The smoke detector consists of a metal cylinder some 8 in. long and 2 in. in diameter, open at each end, so that air can circulate freely through it, and containing two rectangular metallic capsules, one of which is considerably larger than the other. The detector, only one of which is required for each apartment to be protected, is fixed in a high central position, to which the smoke from a fire would ascend, and the effect of the smoke on the capsules is to cause one to bend more than the other. The differential movement is employed to complete an electrical circuit through a relay, and, by means of the latter, a large electric bell or other alarm signal may be operated. The apparatus can be used either independently or in conjunction with detectors depending on temperature effects, but is said to have the advantage over the latter, that its action is more rapid and reliable. In many fires dense smoke would be produced before any material rise in temperature occurred, and, moreover, the smoke would rapidly fill the whole apartment while the temperature rise would remain purely local for some little time. The inventor of the apparatus above referred to is Mr. Herbert Dickenson, 2, Jasper-road, London, S.E.19.

SULPHUR RECOVERY FROM BLAST-FURNACE SLAG.—Before the war Germany imported about 550,000 tons of sulphur, in the form of 1,000,000 tons of pyrites, 250,000 tons of blende and 30,000 tons of sulphur per year. When the imports were stopped, various processes were worked out for recovering sulphur from the natural calcium sulphate (gypsum and anhydrite), and also from blast furnace slag. The annual slag production of the country amounted to about 20,000,000 tons, and the slag contains an average of 1·5 per cent. of sulphur; some 300,000 tons of sulphur were therefore dumped with the slag every year. The recovery process which Dr. L. H. Diehl has developed in the Gutehoffnungshütte promises to survive the war period; it was described in Stahl and Eisen of June 23 last, pages 845 to 852. Slag contains sulphur mostly in the form of calcium sulphide, and this sulphide can be oxidised by air and also by sulphates such as gypsum. The metasilicate of the slag is then converted into the calcium ortho-silicate Ca_2SiO_4, while the sulphur is liberated as such or as SO_2. Calcium sulphate and calcium sulphide can co-exist in the solid condition, but not in the molten state; when gypsum is added to fused slag, SO_2 is liberated. "Though the reactions are not quite so simple as they may appear, the Diehl process consists simply in blowing hot air through the fused slag as it tapped from the blast furnace and before it enters the granulation tanks or is otherwise treated. The oxidation chambers used are firebrick tanks, 3·5 m. long, 0·6 m. wide, 1·7 m. high (11½ ft. by 2 ft. by 5½ ft.), partly covered by a vault, but overtopped by a shaft for charging in the anhydrite; the slag itself is dumped in at the open end, where the bottom slopes upward, and is discharged through a tap hole at the other end. The air is injected at a pressure of about 15 cm. of mercury (7 in.) through slits in the bottom. At first, nozzles were tried, projecting into the slag; but they were easily clogged with slag and corroded, and it was also observed that narrow slots, 5 mm. (0·2 in.) wide, were far less likely to get clogged than round holes; the air vents now used are blocks of hematite iron, cast with ducts for cold water, and fixed flush in the bottom of the tank. The treatment takes from 10 min. to 25 min. The hotter the slag, the more complete is the recovery of the sulphur, which averages 50 per cent. and may be complete when anhydrite has been added to the slag. The air escapes very hot, near 950 deg. C. (1,740 deg. F.) and contains about 10 per cent. by volume of SO_2. A white salt settles in the iron pipes for used the hot gases; this salt is essentially potassium disulphate $KHSO_4$, and contains only a small percentage of $NaHSO_4$; the salt volatilised from ferro-manganese furnaces is also essentially an acid potassium sulphate.

72-IN. REFLECTING TELESCOPE AT THE DOMINION ASTROPHYSICAL OBSERVATORY, VICTORIA, B.C.

CONSTRUCTED BY THE WARNER AND SWASEY COMPANY, ENGINEERS, CLEVELAND, OHIO, U.S.A.

(*For Description, see Page* 207.)

FIG. 8. VIEW OF TELESCOPE FROM THE SOUTH-WEST, SHOWING OBSERVING GALLERY & WIND SCREEN.

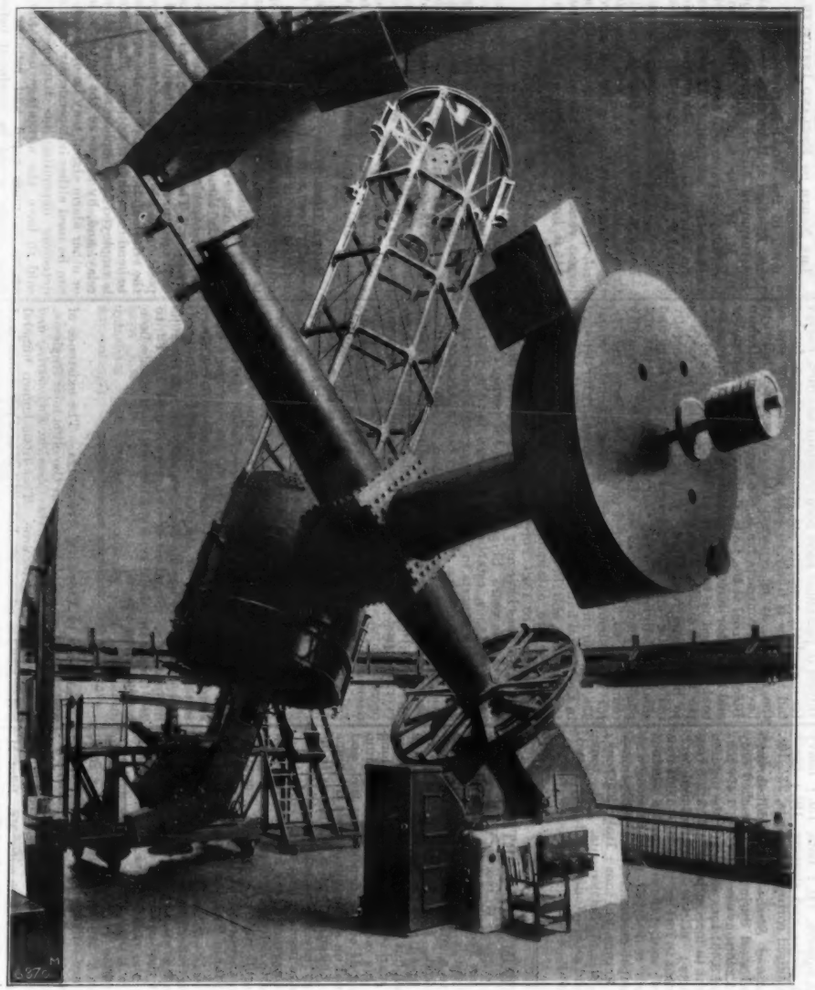


FIG. 9. VIEW OF TELESCOPE FROM THE NORTH-WEST, SHOWING POSITION OF DRIVING CLOCK.

NEW TYPE OF MOTOR LIFEBOAT.—A new type of motor lifeboat recently completed by the Royal National Lifeboat Institution proceeded under her own power from the building yard at Cowes to her station at Eastbourne. She has been specially built for experiment at Eastbourne to meet the launching conditions on that part of the coast, and was launched from a carriage, instead of down a slipway. She is a self-righting boat, 35 ft. by 8 ft. 6 in., fitted for experimental purposes with a Miller engine to be used as an adjunct to her sails. This engine develops 15 h.p., and gives her a speed of 5·9 knots. The boat has been built out of the general funds of the Institution. Four motor lifeboats have now gone to their stations this year, making a total of 29 motor lifeboats at present on the coast, of which 10 have been completed since the war. Two others are nearing completion, and 12 more are under construction. The Institution is pressing forward as rapidly as possible with its important programme of construction laid down in 1917, but the very serious financial situation, and the fact that the Institution, as a result of building motor lifeboats, has already overspent its income this year by 80,000*l.*, may considerably delay the completion of the programme.

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(*For Description, see Page* 207.)

Fig. 1. General View of the Observatory.

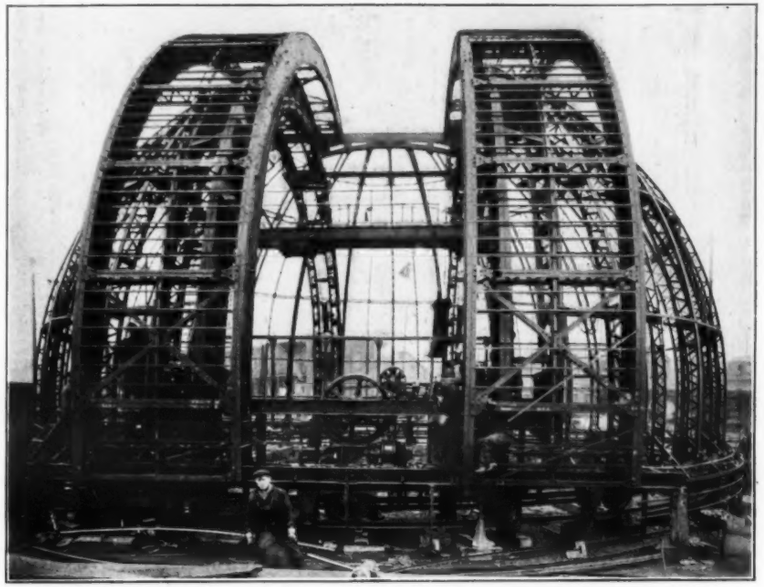

Fig. 2. View of the Dome taken during Erection.

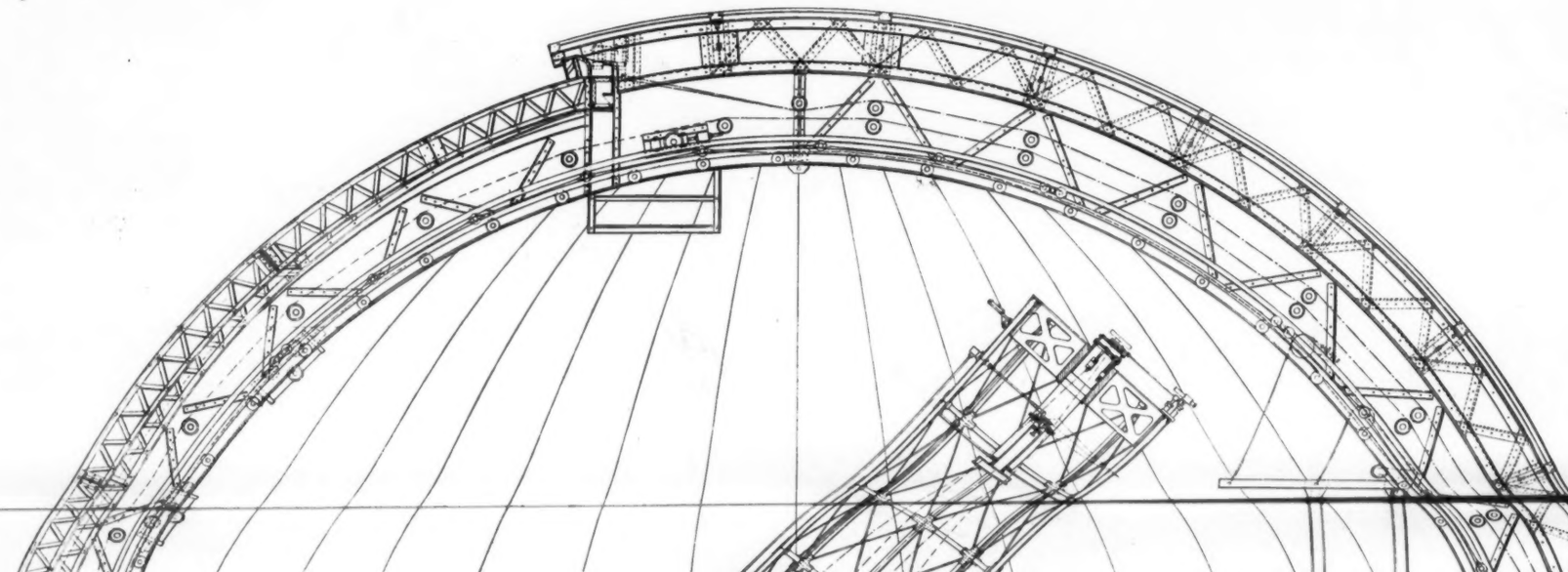

Fig. 3.

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ADVERTISEMENT RATES.

Advertisements intended for insertion in the current week's issue must be delivered not later than First Post on Thursday. In consequence of the necessity for going to press early with a portion of the edition, alterations for standing advertisements should be received on the Friday previous to the day of publication.

The charge for advertisements classified under the Headings of Appointments Open, Situations Wanted, Tenders, &c., is four shillings for the first four lines or under, and one shilling per line up to one inch. The line averages seven words. When an advertisement measures an inch or more the charge is 12s. per inch. Payment must accompany all orders for single advertisements, otherwise their insertion cannot be guaranteed. Terms for displayed advertisements on the wrapper and on the inside pages may be obtained on application. The pages are 12 in. deep and 9 in. wide, divisible into four columns of 2¼ in. in width. Serial advertisements will be inserted with all practicable regularity, but absolute regularity cannot be guaranteed.

SUBSCRIPTIONS, HOME AND FOREIGN.

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Foreign and Colonial subscribers receiving incomplete copies through newsagents are requested to communicate the fact to the Publisher, together with the agent's name and address.

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NOTICES OF MEETINGS.

Notices of Meetings to take place during the present and next week will be found on page 221.

ENGINEERING.

FRIDAY, AUGUST 5, 1921.

PARLIAMENT AND THE NEW BATTLE CRUISERS.

THE House of Commons on Wednesday, after a debate, during which little that was new emerged, passed the shipbuilding vote for the year and authorised the building of four new battle cruisers to replace a similar number of capital ships which have become obsolete and thus fall to be sent to the yard of the shipbreaker. Only the extreme financial straights in which the nation finds itself can be raised as objection to this policy, but it must be conceded on all sides that imperial security is a first essential to national solvency. The Financial Secretary of the Admiralty, Mr. Amery, was compelled to agree that the Navy, which had saved the Empire and, indeed, the world in the great war, was not to-day in that position of sea supremacy, especially in respect of capital ships, which our insular position and our scattered dominions made imperative. Against our one post-war capital ship—the only first-class armoured ship laid down by us in seven years—the Hood, which embodies only some of the teaching of modern war experience, the United States have completed one post-war capital ship and will soon have another, with nine more to be finished by 1922, while financial authorisation has been made for six battle cruisers to be laid down. Japan is in an analogous position, having provided for eight ships to be finished in 1925 and eight more in 1928. These ships are all of great size and power, of between 40,000 tons and 45,000 tons, with 16-in. guns. As our ships are purely replacement vessels and do not add to our total number of available ships for war, it can scarcely be said, even in view of the Washington Conference on disarmament that our procedure is provocative. It is no more than simple prudence.

Although the discussion was participated in by three admirals—a unique incident in the history of Parliamentary debates—and was consequently perhaps more intelligently technical than usual, there was nothing urged to shake the steadily growing view that the capital ship is the basis on which sea power depends. Mr. Amery clearly expounded the considered view of the Admiralty on this question—the result of long and careful analysis of war experience by an Admiralty Committee presided over by Lord Beatty, now the First Sea Lord. To quote Mr. Amery's words: "As between surface ships there could be no possible doubt as to the immense advantage which larger, more heavily gunned, more powerfully armoured ships possess. Coronel, Falkland Islands, and Jutland put that beyond doubt. The real issue was whether the submarine and aeroplane had yet reached a point of development at which the original surface ship had become out of date. The submarine undoubtedly was a very formidable engine of war, and it was one which had come to stay; but its power lay in concealment, and for the sake of concealment it had to sacrifice speed and offensive and defensive power. For the time being, at any rate, that power of concealment had been most seriously impaired by the remarkable progress made during the closing months of the war and since in scientific methods of submarine detection. The aeroplane had, of course, become an essential and indispensable factor in naval warfare, but it had not yet proved capable of carrying or discharging with accuracy at a moving target and in the face of high-angle fire, projectiles more formidable than those against which the modern capital ship was already protected. Its range was still very limited, and, except for inshore work, it was dependent upon the aeroplane-carrier—in other words, upon a surface ship whose security against other surface ships ultimately rested on the battle cruiser or battleship. The day of capital aircraft or of the capital submarine had not yet come, and until it came the capital surface ship would remain the kernel and pivot of naval warfare. No doubt all those new elements of naval warfare had acquired an increased relative importance. The fighting fleet of the future could no longer be reckoned in terms of ships of the line. It was a great complex of highly diversified and specialised units, each of which was indispensable to the defensive and offensive part of the whole."

As we are fairly strong in the lesser craft, excepting perhaps submarine boats, the Admiralty do well to spend such money as can be afforded in replacing obsolete capital ships. The new ships, the House of Commons was informed, are to be improved "Hoods"; but beyond this little information was given as to the features of design. The only definite point was that they are to have 16-in. guns like the new United States and Japan ships. Hitherto the largest guns fitted to our ships have been of 15-in. calibre, except for a trial of 18-in. guns in one of the big cruisers built early in the war and subsequently converted into an aeroplane carrier without big guns. The dimensions of the new "Hoods" will be "such as to keep them within the limits required to obviate the necessity of larger docks." Much was made of the paucity of docks of adequate size in those areas in which our future naval needs may demand the presence of these ships for tactical or policy reasons. But to such existing naval bases floating docks of suitable lifting capacity can easily be sent. Mr. Amery had something to say of Sir Eustace d'Eyncourt's experiments on bulges, dating from 1913, and was able to show that they were completely successful, so that the new vessels will be fitted with these, although they will conform to the lines of the ship instead of being outside as adopted in recently-completed ships subsequent to the completion of the designs of the hull. All four ships will be built in private yards, and it was stated that there are six firms able to undertake them and to compete for contracts, which would probably be based more or less on the "time and line" system. The Estimates allow for the expenditure during the year of a total of 529,980*l.* on two of them. Of this sum, 177,500*l.* is for hull, 105,000*l.* for propelling machinery and 227,800*l.* for armament. On the other two only 359,144*l.* is to be expended. This is far short, of course, of the total cost, as the vessels are expected to take three and a-half years to complete. The only indication of possible cost is the fact that the Hood involved an expenditure of 5,672,039*l.* Claim was, of course, made by dockyard town members of Parliament for the building of two of the ships, one at Portsmouth and the other at Devonport, but it was pointed out that the increase in size and the adaptation of building berths at these establishments would delay the laying down of the ships by twenty to twenty-four months and the expense incurred would be nearly a million for the two berths. The financial situation does not justify this expenditure, apart altogether from the question as to the relative cost of shipbuilding in private and public yards.

The only other noteworthy point which was brought out in the discussion was the result of the Imperial Conference in respect of naval policy generally. Mr. Amery read the resolution that was passed at the meeting of Prime Ministers:

"That, while recognising the necessity of co-operation among the various portions of the Empire to provide such naval defence as may prove to be essential for security, and while holding that equality with the naval strength of any other Power is the minimum suggested for that purpose, this Conference is of opinion that the method and extent of such co-operation are matters for the final determination of the several Parliaments concerned, and that any recommendations thereon should be deferred until after the coming conference on disarmament."

This, it must be confessed, does not carry this important question much further; but it rests with the Dominions to determine for themselves the aid they will give towards Imperial Defence. The contribution must be voluntary, as it is essential that our Empire strategy and tactics require unity of purpose if not of control. That view had full

support from those responsible for the United States contribution to the allied naval force in the great war.

INDUSTRIAL CASUALTIES.

The difficulty of determining the true bearing of statistics is far from being generally appreciated. The popular writer or speaker is too often obsessed with the maxim that "figures cannot lie," and as one result his deductions not infrequently merely demonstrate the acuteness of that unknown philosopher who was responsible for the converse proposition that there is nothing so fallacious as facts except figures. Even in apparently straightforward cases it is by no means easy to discover whether figures are strictly comparable; although they may have been compiled by the same agency and on the same system. The annual report* on factories, just issued, shows, for example, that as compared with 1913 there has been a large reduction in the number of accidents recorded, but it is by no means certain that the figures are strictly comparable. Year by year it is becoming more and more the practice to treat as potentially dangerous, apparently trivial misadventures which in previous years would have gone wholly unrecorded, but now help to swell the list of accidents. Whilst this policy substantially reduces the apparent rate of improvement there is evidence that the new plan of providing rational "first aid" treatment for all the mishaps of the workshop is materially diminishing the number of accidents which have serious *sequelæ*. It is of course quite true that nine times out of ten a small abrasion or bruise will heal itself; yet in the tenth case sepsis may ensue, and the workman be laid off for weeks. Thus the report states, that the result of introducing four ambulance rooms with trained nurses in connection with factories in Scotland, employing some thousands of operatives, has been that claims on the factory accident fund have diminished so much that it has been found possible to reduce the weekly contribution from 3*d*. to 2*d*. per head and at the same time to increase the benefit from 12*s*. 6*d*. to 20*s*. per week. By similar means a large firm of iron and steel manufacturers have, it is stated, reduced their compensation rate from 17*s*. 6*d*. in 1918 to 14*s*. in 1920. The improvement here is said to have been almost wholly due to the prevention of the septic poisoning of wounds which in themselves were trivial.

It is of interest to note that in this connection, as has often been the case in the past, a good cause has been injured by exaggerated advocacy and the ridicule of the men excited by "scare" placards, akin to those popular with a certain type of temperance advocate, in which gruesome representations are given of cellulitis and gangrene as the inevitable result of neglecting slight injuries. Since every workman knows from his own experience that such injuries will generally heal themselves, these overstatements make him inclined to distrust the whole system, and may dispose him to look leniently upon the pilfering of the first-aid boxes by the more selfish and less intelligent of his co-workers. This latter trouble appears to be particularly rife at docks.

Though the accident list in 1920 was less than in 1913 it was more than in 1919, the relative figures being 124,623 accidents with 1,385 deaths in 1919, and 133,773 with 1,404 deaths in 1920, although this latter year is classed in the report as one in which the keynote of trade was "black depression," whilst in 1919 the manufacturing activity was very great, at any rate in the earlier months of the year. We believe, however, that in the report for 1919 the inspector expressed doubts as to whether the returns were complete, and the apparent setback may in consequence be merely a matter of better records. In any case it is gratifying to note that only one-third of the total accidents were due to machinery and that of the remainder not more than one-third could have been prevented by better fencing. In this regard the report notes a steady improvement. Machine builders are more and more adopting the plan of incorporating efficient guards with their machines in the first instance, instead of adding them subsequently as a makeshift. The difficulty of getting either managers or employés to realise the danger of plain unfenced shafting still continues, and men are frequently found at work in close contiguity to such shafting. Two cases are mentioned in the report in which the men owed their escape from death to the weakness of their clothing. In one instance the victim was stripped nearly bare. No doubt the difficulty here is similar to that experienced in persuading men to have trivial wounds attended to, viz., that the neglect of precautions is comparatively seldom serious, though when by exception a man is caught and whirled round by a revolving shaft the accident is commonly of a particularly horrible character.

It is disappointing to note that little progress is being made in the matter of establishing works' safety committees. The men are not enthusiastic in the matter and many employers are opposed to the system. In this we conceive they are mistaken, as here is to be found one of the cases in which an association of masters and men in management is free from the difficulties that arise in co-partnership schemes, which have so far proved practicable only where the successful conduct of the business does not necessitate the acceptance of "gambling" risks, and where consequently the prospect of any large profit is small. It is those who break away from precedent that found new industries or develop old ones, and to do this individual initiative is required, which cannot be exercised when the management is in a quasi-trustee position for a number of small shareholders. On the business side, therefore, there are great difficulties in associating workmen with the management, but nothing but good can come from a union of the two in diminishing the risks of the industry. In this connection it is of interest to note from the report that the Joint Industrial Council for the wire-drawing industry, when it was proposed to apply to this trade the welfare order for galvanising, took the view that they would prefer to deal forthwith with all the processes of the trade. Accordingly a sub-committee has, in co-operation with an Inspector from the Home Office, gone fully into the matter, and has prepared a scheme for improving the working conditions in the trade generally. This is to form the standard with which firms engaged in the industry will be expected to comply.

One interesting result of the era of high wages is noted in the report, from which it appears that there have been many cases in which small employers have dismissed all their men, and now take in only such work as they can carry through themselves. In other cases they have solved their immediate difficulties by taking one or two of their best hands into partnership and getting rid of the remainder. From one point of view this change is for the better, as it has always been with the small employer and not with the wealthy capitalist that the greatest difficulty has been found in improving working conditions. If, for instance, the same standards were applied to the small Sheffield tenement factories, as are insisted on in the case of large establishments, the proprietors would have to go out of business altogether.

It is cheering to learn that at length a real effort is being made to improve the disgusting sanitary accommodation which has been too common in factories situated outside the London area. At length it appears the local authorities are taking action on their own initiative, without waiting for an impulse from the Factory Inspector. Of course, part of the trouble has lain in the lack of self-respect of a certain small minority of the workmen, which makes it necessary to appoint an attendant specially charged with the duty of keeping matters in order. It is the same difficulty which delays the introduction of proper lavatory accommodation in many works. It has frequently happened that excellent provision has been made by the firm, but in the absence of a regular supervisor soap and towels have been stolen and the fittings wrenched off and sold for scrap. Even when dining rooms are provided similar results have followed, and it appears in all cases essential that there should be a supervisor, whose task will be lightened by the fact that he can rely on the support of the vast majority of the men and also of the trade unions concerned. The report, indeed, states that in one case, when appeal was made to the unions, the firm was informed that they had already received complaints on the same head from their own members and would give all the assistance they could to stop the evil.

In view of the increasing use of electricity for power purposes it is surprising to learn that even large firms fail to realise the advisability of employing a competent electrician to oversee the plant. The report states that first-class plant is often provided, but the lay-out is often deplorable; whilst the care of it is entrusted to promoted millwrights and engine tenters, who at times make really dangerous modifications. A common practice is to replace the fuzes or cut-outs by heavy copper links, and in general to render inoperative all the safeguards carefully provided by the makers. At one large Scotch engineering works, where over 200 motors, ranging in capacity up to 50 h.p., were installed, no electrical engineer was employed, the manager declared that he had had them and found they had nothing to do, which in itself is probably indirect testimony that the plant was being kept in order. This, it appears from the inspector's report, is certainly not the case at present. Electric cranes are coming more and more into favour. They have one great advantage in that the crane cannot be overloaded, as the fuzes will blow if the attempt is made to lift too great a weight. Unfortunately, this too frequently leads to the replacement of the fuze wire by solid copper.

Crane accidents in general have been numerous, and are frequently serious. A considerable proportion are due to loads being improperly secured and falling out of the slings. A fair number have been due to the failure of slings, hooks or chains, but considering the nature of the treatment they receive it is remarkable that chains stand so well as they do. The nominal stresses on them, as calculated by the mathematical theory of elasticity are, under ordinary working loads, of the order of 30,000 lb. per square inch, and when a load surges, the nominal stress must be considerably higher. Moreover, high as is the nominal working stress, sanctioned by long experience, cases of overloading are far from infrequent, and the report mentions a case in which the safe load for a $\frac{3}{4}$-in. chain was entered in the owner's books as $6\frac{3}{4}$ tons, whilst a $\frac{9}{16}$-in. chain was similarly rated as safe for $3\frac{3}{4}$ tons. In fact, experience with chains affords a striking exemplification of the truth of the contention that there is no *a priori* method of fixing the working stresses on our materials of construction.

Factory lighting is often deficient. Some firms seem to think it less costly to use artificial light than to keep their windows clean, and the illumination provided is poor in the extreme. In this regard, however, there has been an enormous improvement during the past thirty-five years. A generation or so ago the fitter or erector who had to work in a dark spot, had no light save that afforded by a tallow dip stuck into a $\frac{1}{2}$-in. nut. Now he commonly has a portable electric lamp. These, however have some drawbacks of their own, as the drawn-wire lamps, especially if of high efficiency, should be shielded. This is not always efficiently done, and eye troubles result. Another form of eye trouble is experienced in glass works, where the operatives are prone to cataract. This, it appears from the report, is not due to the ultra violet light which causes the trouble with the $\frac{1}{2}$-watt lamps and in arc-welding operations, but is the indirect effect of a very prolonged exposure to the heat rays which, it appears, check the proper nourishment of the lens.

Owing to the depression in trade relatively little overtime has been worked during the year under review, and even in seasonal trades such as fish-curing at Lowestoft and Yarmouth, it has been found that the extremely long hours formerly prevalent were unnecessary, and not conducive to output. As regards reduced hours generally, however, the evidence is conflicting, and in many cases the maintenance of output after the reduction of the hours worked is attributed to better time-keeping. In some foundries the five-day week system has been adopted, as it has been thought unprofitable to start up the furnaces on Saturdays for a mere 4 hours to 4½ hours. The single-break day is popular

* *Annual Report of the Chief Inspector of Factories and Workshops for the Year* 1920. H.M. Stationery Office. Cmd. 1403. Price 1*s*. 6*d*.

with employers, but not in all cases with the men, as it implies long spells of continuous work. Cases are recorded in the report in which output has been improved by arranging for a short 5 minutes to 10 minutes interval at mid-time, and in some instances arrangements have been made for tea or cocoa to be obtainable at these breaks.

WAGES, PRICES AND PRODUCTION.

MANY platitudes have been spoken and written on the subject of wages and production. We have been told over and over again that the prosperity of the country depends on production, and this is fairly obvious, for after all the best that can be done is that the production of the country shall be divided among the inhabitants. With regard to the mass of the inhabitants also the thing that matters is the relation of wages to prices. The actual wages and prices matter very little, what really makes the difference as regards the standard to which the people can live is the relation of the two. Thus if in one country a man has to put in three days work to pay for a watch, and in another can buy an equally good one with what he earns in a day, watches are cheaper to him in the latter country than the former whatever the actual money values of wages and watches may be. The same applies to other commodities. Now it is obvious that this depends mainly on production. If it takes labour to the equivalent of three days to make a watch it cannot possibly be bought for a day's pay.

All this has been said over and over again yet it remains a fact that the production of this country is very far from what it might be, and it is therefore interesting to study what can be done in the way of production, if it is really well organised and those engaged in it are willing to help to turn out the maximum possible.

For this purpose we may take the production of articles in the United States of America and, for purpose of comparison with Europe it is best to take a trade of modern growth and one in which the initial steps were not taken in the United States of America. In the case of trades of long development such as the shipbuilding trade, tradition helps the countries in which they started to a very great extent. In some special trades such as the type-writer trade, the fact that the machine was invented in one country may be said to give that country a great advantage.

There is, however, one very large manufacturing trade which has developed in quite modern times, and in which no country has had any very great advantage in the first steps, and that is the motor trade. This trade has grown up entirely during the last twenty-five years, and all countries started fair. There have been no master patents or great inventions to handicap any particular country. What advantage there has been in the matter of priority of design has certainly been with Europe, where the modern type of car with the engine in front and the sliding gear was worked out while the Americans were still experimenting with horizontal engines and epicyclic gears. Subsequently the Americans took up the European type and have been so successful in manufacture that they make a very large proportion of the cars of the world.

In order to see what can be done in the way of production it is convenient to take the year 1916, as this was before America came into the war and before the prices had been disturbed by her doing so. In considering these prices it must be remembered that even in those days American wages were very high indeed compared with those ruling in Europe. It is hardly necessary to go into this question as it is quite well known that American wages were then far the highest of any large country in the world.

When English people talk of American cars they are rather apt to think only of Fords. Now the Ford is a very wonderful production, and will be referred to later, but its construction is somewhat special and it is not therefore strictly comparable with the ordinary European car. On the other hand, America produces a very large number of cars which have the conventional European arrangement of a clutch, sliding gear, &c., and which are therefore quite comparable with the European car. Many people are also under the impression that all the American cars are a very rough, cheap job, and badly made. Naturally the very cheapest American car will not compare favourably in finish with the highest type of English car, especially as to the body work, but even very cheap American cars are very sound in their main working parts, while the more expensive cars are very well made indeed.

The annexed table gives particulars and prices of some of the representative American cars made in 1916. These are all of the ordinary European type with three speeds, sliding gear, live axle and bevel drive. All prices include a side entrance body with hood and curtains, &c. In all cases a complete outfit of electric light is provided and also electric self-starter. Detachable rims are usual and also speedometer. In fact, the price of the car is complete with modern equipment, and ready for the road.

American Cars, 1916.

Name.	Cylinders. No.	Dia. In.	Stroke In.	Capacity. Cub. In.	Price. Dols.	£
Briscoe ..	4	3 7/8	5½	190	750	155
Briscoe ..	8	3 7/8	5½	380	950	198
Buick ..	6	3½	4½	224	985	205
Buick ..	6	3½	5	331	1,485	310
Apperson ..	6	3½	5½	295	1,550	325
Apperson ..	8	3½	5	368	1,850	385
Cadillac ..	8	3½	5½	316	2,080	430
Cole.. ..	8	3½	4½	346	1,595	330
Dodge ..	4	3½	4½	212	785	162
Detrotter ..	4	3½	4½	187	985	207
Hollier ..	8	3	4½	240	985	207
Hudson ..	6	3½	5	288	1,375	285
Hup ..	4	3½	5½	242	1,085	225
King ..	8	2½	5	259	1,250	260
Kearns ..	4	2½	4	95	450	94
Maxwell ..	4	3½	4½	185	655	136
Monroe ..	4	3 1/16	3½	110	485	103
National ..	12	2½	4½	336	1,900	413
National ..	6	3½	5½	303	1,600	352
National ..	6	3½	5½	364	2,375	493
Overland ..	4	3½	5	153	615	128
Overland ..	4	4½	4½	240	750	156
Overland ..	6	3½	5½	303	1,145	240
Oakland ..	6	2 13/16	4½	177	795	165
Oakland ..	4	3½	5	197	1,050	218
Oakland ..	8	3½	4½	346	1,585	382
Packhard ..	12	3	5	424	2,750	572
Paige ..	6	3½	5	230	1,050	218
Paige ..	6	3½	5½	303	1,295	268
Pathfinder..	12	2½	5	389	2,475	515
Peerless ..	8	3½	5	331	1,890	392
Pierce Arrow	6	4	5½	414	4,300	895
Pierce Arrow	6	4½	5½	524	4,900	1,050
Pierce Arrow	6	5	7	824	5,900	1,230
Regal ..	8	3	4½	254	1,200	250
Regal ..	4	3½	5	220	950	198
Saxon* ..	4	2½	4	95	395	82
Saxon ..	6	2½	4½	175	785	165
Standard ..	8	3	5	282	1,735	362
Standard ..	6	4	5½	414	2,100	435
Studebaker ..	4	3½	5	235	885	184
Studebaker ..	6	3½	5	375	1,050	218

Above prices are complete with ordinary four-seated body, except in the case of a few of the very small cars like the Saxon. They also practically always include hood, screen, electric light and self-starter, and usually detachable rims.

English prices are taken at the normal rate of exchange then existing, namely, 4·8 dols. to the £.

* The small Saxon has only two speeds.

Beginning with the cheap cars, we may take the Maxwell, priced at 655 dols., or 136*l*. Considering that this car has electric light, self-starter, &c., there is no doubt that this was a wonderfully low price. It had four cylinders, 3½ in. by 4½ in., and, of course, four-seated body, hood, screen, &c., are included.

Coming to a better and more expensive class of car we have the Buick. This is well known in England, where it has a very good reputation. It had six cylinders, 3½ in. by 4½ in., with overhead valves, and therefore by no means a cheap type of engine to build. Delco electric lighting and self-starting were fitted, this being a system of the very highest reputation. The car was sold complete with full-sized body, hood, screen, &c., for 985 dols., or 205*l*.

A smaller car of the same general characteristics as the Buick, having six cylinders and overhead valves, is the Oakland, and this was sold complete with electric light and self-starter for 795 dols., or 165*l*.

A great deal used to be said of the inferior work and material in these cars. As to this it may be pointed out that the work of some European cars is not anything very marvellous, yet their prices have always been enormously greater than the above. Further, there is yet no evidence that the workmanship of these cars was really inferior. Buicks and Oaklands have been on the road in England for a good many years, and a reference to the advertisements in the advertisement columns of the motor papers will show that it is difficult to get either of these makes even second-hand and five years old under 250*l*. or 300*l*. That is to say, they fetch more when five years old than they cost in their country of origin when new.

Coming to a car of still higher type, we may take the Cadillac. This is a large and very luxurious car, having an eight-cylindered engine with cylinders 3½ in. by 5½ in. The eight-cylinder engine is not at all a cheap type to build as the connecting rod of one cylinder is forked and runs on the outside of the brass of the other connecting rod. In this case the forked connecting rod is machined all over to reduce the weight and is therefore a very expensive part to produce. Moreover, the workmanship of this car is of the very highest class all over, and a great deal of care is taken in its construction from start to finish. It is, of course, a large car weighing something over 35 cwt., and is capable of very high speed, something in the neighbourhood of 70 m.p.h. It was sold fitted with a large side entrance body with elaborate hood and side curtains, detachable rims, very large tyres, tyre pump worked by the engine and, of course, electric light and self-starter, for 2,080 dols., or 430*l*.

Coming again to a still more elaborate car we find the twelve-cylinder Packhard having cylinders 3 in. by 5 in., sold for 2,750 dols., or 572*l*. This is a very large luxurious car, whose reputation is too well known to need emphasis, and the amount of work in a twelve-cylinder engine is obvious.

The above are all cars with side entrance, five-seated bodies. When we come to the small two-seater, we find that the Saxon, a car well known over here, was sold for 395 dols., or 82*l*., no self-starter being included in this case. This car has a four-cylinder engine having cylinders 2½ in. by 4 in., and has the usual clutch and sliding gear, two speeds only being provided with a reverse.

As mentioned, the Ford stands in a class rather by itself, as it has special types of transmission and ignition. Nevertheless it is a full-sized car having a body which will really seat five people, and it was sold for 440 dols., or about 90*l*.

Now without going into elaborate details it is evident that these prices are very remarkable, especially when the high rate of wages in the United States of America is considered. It is, of course, impossible to directly compare the prices with those ruling in Europe at the time as in 1916 all the principal countries this side of the Atlantic were engaged in the war. It may, however, be safely said that even if the war had not occurred cars would not have been made here for anything like as low prices as the above, even though the wages paid were very much lower. In fact, it is not likely that similar cars would have been turned out for much less than double the above prices.

As mentioned, the car trade has only been taken as a sample of what can really be done in the way of cheap production combined with high wages. Naturally also car prices at the moment are inflated in America as elsewhere. Part of this inflation is, of course, due to the exchange, which, however, does not affect the question of the relation of cost to wages. Prices of cars are, however, coming down. In fact, the Ford is now at the same price as before America came into the war, namely, 440 dols.

It is quite clear that these prices are very well worth the careful study of all those interested in any of the small engineering trades. What is true of car production will be true of all the various articles of the smaller kinds of engineering which are turned out in quantities, and these are becoming the most important engineering productions of the world in many ways. Whether the causes of this cheap production in America are organisation, labour, taxation system, or other causes, it is quite clear we must reduce our costs in proportion if we are to hold our position in the world.

10-FT. WIND TUNNEL.—The aerodynamic section of the Bureau of Standards, says *Engineering News-Record*, New York, is constructing a new wind tunnel, 10 ft. in diameter. The design for the tunnel is completed, and material for construction is being assembled.

NOTES.

Bristol University.

The University of Bristol is issuing an appeal for 1,000,000*l.* to place it in a position to carry out its work with less handicap than it is experiencing at the present time. The original endowment provided by the citizens of Bristol amounted to 224,000*l.* The endowments thus provided now meet less than half the expense of maintaining the professorial chairs to which they are applied, while in many cases chairs are not endowed at all. The University serves the whole of the South-West of England, and embraces instruction in modern as well as classical subjects. The Faculties of Science and Engineering are particularly active. In the last connection it is interesting to note that Bristol is the only University in England possessed of a school of automobile engineering. Touch is maintained with the practical side of engineering by conducting commercial tests and industrial researches, and by specially-arranged courses in which the university students spend a large part of their time in works. We are sure that the west country which has produced so many men of mark in England's history, and so many thousands more who have become Empire-builders in a less conspicuous way, will not allow its great training school long to suffer the handicaps which now beset it. We further commend the appeal to all whose success in life has been the result of practical thoroughness, a characteristic which we believe it is the especial endeavour of Bristol to develop.

Electric Supply Progress.

The setting-up of Joint Electricity Authorities progresses but slowly, and the financing of the whole scheme of work for which they stand is likely to be seriously delayed by the failure to proceed with the new Electricity Bill. In spite of these handicaps, however, a recent report of the Minister of Transport suggests considerable activity in electric supply circles. The report covers the period from June 27 last year to March 31 last. It deals with the work of the Electricity Commissioners and the various consents and approvals which the Minister has given on the advice of the Commissioners. In the matter tabulated it is interesting to note that 29 authorities have been empowered to erect overhead lines in specific cases. These powers mostly apply to rural districts, but the Clyde Valley Power Company is included as well as the authorities in Burnley, Huddersfield, Kingston-upon-Hull, Leicester, Runcorn and St. Helens. Some 160 corporations and supply companies have been authorised to increase their maximum prices, while new generating stations have been authorised to the extent of an initial power installation of 150,000 kw., and extensions of plant to the total of 550,000 kw. Some 500 local authorities have applied for borrowing powers in connection with their electricity supply undertakings, and total loans to the extent of 15,181,298*l.* have been sanctioned. In 10 cases the Commissioners have approved agreements for mutual assistance or the taking of bulk supplies between authorised undertakings, while 71 "fringe" orders have been made permitting the supply of electricity outside scheduled districts. The work of the Commissioners in connection with the setting-up of Joint Authorities is to be made the subject of a special report.

Water Power in Canada.

Attention is often attracted to the enormous potential resources of Canada as regards hydro-electric power. A large part of the Dominion, though meagrely supplied with coal or liquid fuel, has been blessed with ample water power, which will doubtless be increasingly developed, though many of the sites are too remote to be utilised in the immediate future. A revised estimate has lately been made by the Water Power Branch of the Department of the Interior, taking into account such cases only on which some definite information exists. The figures give, therefore, minimum possibilities, and in no sense the maximum limit. Two bases have been taken; one the ordinary minimum flow, and the other the estimated flow for maximum development, taken as for a period of six months, the other half year's supply being drawn from storage, &c. The former is calculated on the average minima for two consecutive seven-day periods in each year. The latter is calculated on the flow of the lowest seven days of the lowest month's flow among the six months showing the best flow. Taking first the ordinary minimum flow the available 24 hr.-horse-power at 80 per cent. efficiency is about 18¼ millions, of which nearly 7 millions are available in Quebec, nearly 5 millions in Ontario, and 3½ millions in Manitoba. British Columbia has nearly two millions. However, on the maximum development basis the figures are very much larger, totalling over 32 millions horse-power, of which Quebec possesses over 11½ millions, Ontario nearly 7 millions, Manitoba and British Columbia each between 5 and 6 millions, and Alberta and Saskatchewan over one million each. As yet only about 2½ millions have been utilised, the bulk, nearly two millions, being due to installations in Ontario and Quebec, the former having just over, and the latter somewhat less than, one million horse-power installed. The only other province at present taking advantage of its resources to any extent is British Columbia, with 300,000 horse-power.

Volatilisation of Refractory Substances in the Electric Arc.

A very interesting account of an extensive series of experiments on the "Relative Volatility of Refractory Materials" was communicated to the American Electrochemical Society by Mr. W. Roy Mott, of the National Carbon Company, Cleveland, Ohio, in 1918, and a further communication by Mr. Mott on the subject appeared in the latest thirty-seventh volume of the Transactions of that Society under the title "Arc Images in Chemical Analysis." Mr. Mott drills a hole, $\frac{3}{8}$ in. in diameter and depth, into the lower positive arc carbon—ordinary high-grade enclosed arc carbons, ½ in. in diameter, not containing more than 0·1 per cent. of ash—places about 0·5 gramme of the substance into the carbon cup and starts the 25-ampere arc at 50 volts on a 110-volt direct-current circuit. The material is then volatilised; the most refractory residue remains in the cup, the vapours condense on the lower and upper carbons in beads, mirrors or rings, partly of exceedingly fine particles, the least volatile close to the crater, and conclusions as to the volatility are drawn by measuring the distances of the deposits from the carbon tips or from distinct rings of iron, &c., first deposited, and from other features. The measurements are made on pin-hole images of the arc, and time, brightness, structure of the deposits and colour phenomena are observed. The experiments are modified in various ways. A pure substance is first volatilised; it is then mixed with various other substances in different proportions for new measurements. Or a negative carbon is coated, say, with copper, by arc distillation, and the coated portion is then reheated in the arc, for 2 minutes; a certain measured portion of the copper will be revolatilised. Or the arc is interrupted while volatilisation is proceeding; the hot carbons will then continue to "smoke" for measured periods of seconds or minutes; this method is applicable only to substances boiling below 2,000 deg. C. In these ways it is found that metals, not forming carbides, will distil in the order cadmium, zinc, thallium, lead-bismuth (these two metals distilling together), antimony, silver, tin-copper, gold; the iron metals, Ni, Fe, Co, Cr (except Mn) are also superposed and cannot be separated by these methods. Most of the metals are deposited as oxides. In estimating the boiling-points Mott assumes—from the observations of his own and of others—that the temperature of the carbon crater is 3,700 deg. C., and that tungsten boils at 6,000 deg. C., iron saturated with carbon (like all the metals) at 3,500 deg., silica at 3,500 deg., aluminium oxide at 3,700 deg., chromium carbide at 3,800 deg., platinum at 4,050 deg., zirconium oxide at 4,300 deg., thorium carbide at 5,000 deg., and tantalum or its carbide at 5,500 deg.; in the case of tungsten a fusing carbide seems to be formed, but the carbon boils away. Materials boiling below 2,500 deg. C. generally give long, steady arcs, more refractory materials give unsteady arcs, partly owing to variable cratering. Hydrogen compounds, such as water, ammonium salts, organic compounds, volatilise readily and yield short unsteady arcs; fluorine can be identified in the presence of calcium by the green band in its arc spectrum; iodine is recognised by its odour and its purple vapours; boron and phosphorus colour the flame tip green; boron also gives a green flame core with a yellow-red shell; metals increase the arc length; in the uranium arc flame blue, green and red colour zones appear. There are many other characteristics which enable Mott to detect 0·02 milligramme of gold and tungsten, and 0·1 milligramme of the rare earths by this rapid arc analysis. Mott has in fact worked out a system of analysis by arc images covering a large domain of inorganic chemistry, which looks promising for routine analysis as well as for research.

The Embrittling of Steel by Cleaning and Pickling.

During the war the United States Bureau of Standards inquired into the embrittling effect of the cleaning and pickling which steel has to undergo before plating. Little attention has generally been paid to this effect, except in the case of steel springs, because an ample factor of safety is mostly allowed. For aeroplane construction, however, some manufacturers would rather have protected their steel by zinc plating than by copper plating if they had not thought that the former caused greater brittleness. The Bureau intended to study the protection afforded by plating as well. But the research remained incomplete, because Messrs. C. S. Langdon and M. A. Grossman, in whose charge the experiments were, left the Bureau, and for other reasons, and these gentlemen therefore communicated the results of their inquiry, so far as it went, to the American Electrochemical Society (Transactions, vol. 37, pages 543–578). The specimens chosen were rods, from $\frac{1}{16}$ in. up to $\frac{9}{16}$ in. diameter, of steel ranging in carbon contents from 0·08 per cent. up to 0·89 per cent., otherwise fairly uniform in composition, and steel strips, containing from 0·07 up to 0·14 per cent. of carbon, and hence more uniform throughout. The thickness of the strips ranged from 0·0126 in. to 0·0358 in., and they varied also in hardness. The rods were tested raw or after some treatment. The tension tests and Izod impact tests proving unsuitable, an alternating bending test was used, the rod being clamped at the one end and pushed by a clasping tool at the other end, the test length being 2¾ in. The rod was kept cool by wetting it with alcohol; otherwise the steel became hot and the results were not concordant. For the strips, 3⅜ in. square, the Erichsen "workability" test was adopted. In this test the steel is clamped between two dies, and a rounded-off tool is pressed on to the strip, which is bent down until it breaks. The "penetration" of the tool at which the fracture takes place is measured with a micrometer. The samples were first cleaned of grease, either in organic solvents or in an alkaline bath (soda and caustic, with a little resin) applied by immersion, or by the brush and pumice, or electrolytically. The caustic cleaning (mechanical or electrolytic) reduced the penetration by 10 per cent., and the pumice brushing had similar effects, even on the rods. Sand blasting made the rods appreciably weaker, especially those of low or medium carbon contents, though the thickness and weight were hardly affected, probably because a loss of weight was compensated by the embedding of a few sand grains. Pickling for five minutes in twice normal sulphuric acid at 50 deg. C. made the rods brittle, especially if low in carbon; in the tempered steel the brittleness increased with the carbon contents. The sheet steel suffered most when thick and hardened by cold work. The penetration for instance, fluctuated between 8·6 mm. and 8·2 mm. before pickling, and between 6 mm. and 6·6 mm. after pickling. The pickling effect increased as the temperature of the bath was raised to 50 deg. C. (little afterwards), and with the time of the immersion, partly owing to the reduction in dimensions. In acid sodium sulphate (nitre cake), hydrochloric acid and hydrofluoric acid the results of pickling were similar. Nitric acid had no effect on rods, but slightly weakened the sheet metal owing to dissolution. Electrolytic pickling, anodic or cathodic, had, in acid, the same effect as immersion; in neutral sodium sulphate electrolytic pickling had no effect whether the steel was anode or cathode.

As regards treatment after pickling, steel recovers (though sheet metal never does so completely) at ordinary temperatures (in the course of days), and more quickly when warm (in 10 minutes at 150 deg. C.). In boiling water the recovery even of rods takes only a few minutes (two to five). Pickled steel strip never quite attains its original penetration values. The pickling effect is apparently twofold, partly permanent owing to the roughening of the surface, and partly temporary owing to the occlusion of hydrogen. The treatment of embrittled steels with oxidising agents (nitric acid or potassium bichromate), sometimes recommended, did not cure brittleness.

LITERATURE.

Annual Reports on the Progress of Applied Chemistry. Issued by the Society of Chemical Industry. Vol. V. 1920. [Price 15*s.* post free.]

THE retrospect of the year 1920, as it appeared to the compilers of the sections of the Annual Reports of the Society of Chemical Industry, is not brighter than one would anticipate. Almost in every section we read of the unsettled economic and political conditions and of the dearth of materials. Dr. W. B. Davidson, reporting on General Plant and Machinery, calls the year a lean one as regards large schemes requiring new plant in the chemical industry. Messrs. H. J. Hodsman and J. W. Cobb (Fuel) speak of the continued and almost worldwide shortage, but welcome the advance of fuel research which, begun in their own university of Leeds in 1907, is now pursued in the Universities of London, Manchester, South Wales and Sheffield, and by the Fuel Research Board at Greenwich. Technical development in the field of Gas and Destructive Distillation, Dr. G. Weyman states, was greatly hampered by delay in plant supply and labour difficulties. Dr. A. E. Dunstan (Mineral Oils) has to draw attention to the depletion of natural oil stores. Mr. F. M. Rowe (Colouring Matters and Dyes), discussing the dyestuffs Act of 1920, sees the British dyers alarmed by the foreign competition, but does not omit to point out that the dyestuff manufacturers have too frequently confined their consideration to the point of view of the British Dyestuff Corporation, and that the Bill had been said to combine the greatest amount of interference with the textile trade with the least guarantee of encouraging the dyestuff industry. Mr. Sidney Napier (Fibres and Textiles) and Mr. B. Leech (Bleaching and Dyeing) urge some of the latter considerations, but say little on the general economical aspect. Dr. W. E. S. Turner (Glass and Refractory Materials) dwells upon the radical change in the general positions since 1915. Most of the great Powers have enormously developed their glass-making resources, but new factories have been set up also in South America, South Africa, Australia, China and Japan, and these factories are largely machine-operated, whilst Germany, Austria and Czecho-Slovakia are at present perhaps less well equipped with automatic machinery than their competitors. In stating that the year 1921 will decide whether British optical and scientific glass can hold their own, Dr. Turner does not plead particularly for protection of this industry.

In books of this kind, some overlapping of different sections is difficult to avoid, and we should not point out that lubrication is dealt with both in the first general section and in the section on mineral oils, if the former notice were not altogether limited to the so-called germ process. There are several interesting minor novelties in that section. Seiferheld facilitates the atomising of liquid (water for sulphuric acid chambers or for gas washers) by dissolving sulphur dioxide in the water the vapour tension of which is thereby raised, while Balcke hastens the cooling and crystallising of hot solutions by passing endless belts through the solutions; the upper part of the belt which is not immersed is cooled by a current of cold air. The Siemens-Schuckertwerke precipitate the dust of blast-furnace gas by passing the gas through a system of electrodes, arranged in Venetian blind fashion. Another novelty, turbines actuated by mercury vapour in combination with steam, is merely mentioned without naming the originator or affording further explanation of the plan. The Merz-McLellan-Michie-Weeks process of low temperature carbonisation is briefly described, but the patent reference is subsequently given in the section on Fuel. In this latter section attention is drawn to Mrs. Fishenden's research on "The Coal Fire" and the measurement of its radiant efficiency. In the section on Iron and Steel, Dr. J. H. Andrews has nothing to say on the utilisation of slags as fertilisers, though that subject was discussed a good deal last year. Messrs. D. F. Campbell and Colin Gow might have headed their section on Electro-chemical and Allied Industries simply Electro-metallurgy, to which they practically confine themselves.

It is gratifying to note that most of the authors are able to record an increasing appreciation of the value of research. Mr. F. C. Thompson, writing on Leather and Glue, refers with satisfaction to the British Leather Manufacturers' Research Association, and Dr. Bywaters (Foods) deals at some length with vitamines. In Sanitation (Dr. H. T. Calvert) little progress has been made, and one does not quite know whether the fact that the plantation rubber output of the world which, thanks largely to research, now makes up 89 per cent. of the total, according to Dr. H. Stevens, is everywhere regarded as satisfactory; for this year the supply is expected to exceed the consumption by 50,000 tons. We should mention that changes have been made in the compilers of a number of the sections. Mr. T. F. Burton remains Editor of the Report, which this year is published without preface.

Engineering Instruments and Meters. By EDGAR A. GRIFFITHS. London: Routledge and Sons, Limited. [Price 31*s.* 6*d.* net.]

THE history of achievement is always interesting, the study of its processes an education. In this volume we can perceive the progress that has been made in accuracy of production, and follow the application of the principles by which it has been accomplished. The steps along the road to perfection are clearly recognisable, and though in recent times each step may seem small, they crowd together thickly and advance is maintained. The lessons of the war time have been many and instructive; they have especially demonstrated the necessity and the utility of providing accurate measuring appliances for the control of industrial operations, and it is an imperative duty that the experience gained should be made to serve the future welfare of the country. Scientific knowledge is brought to bear upon the affairs of commercial and industrial life by a gradual process, in which three stages can be more or less clearly perceived. There is first of all, pure science research, which like honesty is praised and starved; next, the application of pure science to particular problems carried on in industrial research laboratories, and finally the works laboratory, whose office is to apply appropriate processes, on a commercial scale to control the finished product. The history of science presents many examples that show the small esteem in which members of the first class are held; the successful application of science to industry which may open new outlets for capital and the prospect of immediate reward attract more general recognition. The third member in this scientific combination has not yet attained his merited position. He renders an essential service in maintaining a high standard of purity in raw material, in testing and checking the quality of product in all stages of manufacture; but such services are not of a sensational character and public acclaim is grudgingly accorded. The author may be regarded as belonging to the third order, or, at least, as one who is anxious to facilitate the work of those who insist on the necessity for accuracy. His authoritative exposition of the capacities and limitations of measuring apparatus is a valuable contribution to the literature of mechanical science. Too often, he reminds us, these limitations are not thoroughly appreciated, there is a tendency to trust to the instrumental record as being absolutely exact, and to regard the instrument as an infallible authority. That is strictly true, and the only remedy seems to consist in the continued improvement of the recognised standards of accuracy coupled with the more intelligent use of the means provided.

The attention given to increased accuracy as exhibited in the construction of gauges and other testing apparatus has effected a revolution in the processes of manufacture. The insistence on exactness of repetition has made mass production possible, for the adoption of such an economical scheme can only be effective when the production of the component parts of machinery proceeds with such strictness and confidence, that the work of fitting and adjustment is entirely eliminated in the process of assembly. It is important, too, to note how greater nicety in the fitting of interchangeable parts demands increasing accuracy in the testing apparatus. If a clearance in a particular class of work, for example, is limited to one two-hundredth of an inch, the tolerances permissible in the several parts must be reckoned in thousandths of an inch. The author puts the ratio even higher. "Starting with a moderate tolerance of one two-hundredth of an inch for the work, has culminated in requiring a master check gauge accurate to one ten-thousandth of an inch." This measurement of such small quantities has become a commonplace of the workshop. It is now readily possible to test the roundness and parallelism of a cylinder within 0·0001 in., and testing instruments are made to read, though possibly not to measure, one ten-thousandth of a millimetre, about the fourth of the wave length of violet light. How this and many other minute measurements are made, Mr. Griffiths explains in a very lucid manner, but it is naturally not possible to reproduce his descriptions. Every page exhibits a mass of facts detailing progress in the art of measuring, and the means "for ensuring greater nicety of construction." The occasional historical remarks are deeply interesting, and we wish they could have been lengthened, but the rapid advances of modern times, to which our columns have borne repeated evidence, have necessarily crowded out the feeble and inaccurate processes that satisfied earlier and less critical ages. It may, however, be perceived that the tools of the nation have always sufficed for the needs of the time. The broken and repaired standard yard of Queen Elizabeth seems to have served its purpose as efficiently as the carefully constructed International Prototype Metre. When new types and innovations make their appearance they herald the approach of a period of marked inventive activity. The establishment of the National Physical Laboratory betokened the passing of an old order, and was the consequence of dissatisfaction with ancient methods, and the demand for the provision of means to meet an era of enhanced progress. How well that Institution has fulfilled its purpose can also be gleaned from these pages.

Very briefly the contents of the book may be indicated. The author begins with the measurement of length, or the correct determination of one dimension, passing to the measurement of the thread of the screw. One of the simplest and most widely used of mechanical contrivances, its career of usefulness has been very intermittent. The Greeks invented it, and it was used in classical times, only as a means of motion. The possibility of a screw and nut for fastening required centuries of preparation, and its use in holding two pieces of wood together is quite a modern invention, and one whose convenience has not penetrated to some instructed nations. But notwithstanding its utility and great value in the measurement of small distances, "the accurate gauging of its threads is one of the biggest problems of metrology." The most effectual method has been found to consist in forming an enlarged image of the cross-section, free from distortion, and then making measurements on the shadowgraph.

Areas next come under consideration, and the author, regarding Simpson's rule and other arithmetical devices for estimating irregular areas cumbersome and onerous, supports the use of the planimeter and gives not only the general theory with some completeness, but describes various forms that have been contrived for special purposes. A good example is that of the arrangement by which the moment of inertia about a given line may be obtained by methods similar to those employed in measuring a simple area. One may learn from this chapter, new uses to which the mechanism

can be put, and this is valuable for, as in sliding scales, the less obvious purposes are often ignored. The amount or percentage of error in any application will depend in great measure on the care and skill of the observer. Mr. Griffiths ranks the accuracy very high and under the best conditions greater than the accuracy of the diagram measured, but he adds the caution "friction at the pivots and maladjustment will very materially influence the accuracy under ordinary conditions of work."

Entering on three dimensional measurements, attention is necessarily centred on the construction of meters, and the number of practical applications by which the volume of water, gas, steam, and even solids is achieved, is legion. Add the difficulties of registration and calibration, with the sources of error that accompany each, requiring new combinations to effect the necessary eliminations, and it is evident that we have the materials for a chapter both important and varied. With not a little ingenuity, the author brings the mechanical details into three distinct classes according to the basic principle of operation; "I. The displacement type, in which a chamber is charged and discharged alternately; II. The continuous flow type, which involves the measurement of the velocity of the stream and a mechanism for integrating the flow over a time interval; III. Miscellaneous instruments, utilising some thermal property of the fluid and suitable electrical devices for recording such changes. There may be combinations of these in certain forms of measuring machines, but the preservation of broad divisions lends itself to methodical arrangement and lucidity. The discussion of gauges finds a place here, and among those described is one designed by the author, a liquid depth gauge for use in aircraft which, we gather, gives satisfaction. Its object is to overcome a source of error which arises in indicating the level of liquid in tanks when the depth varies owing to the inclination of the tank to the horizon. The indications are based on the principle that the heat loss from a hot wire immersed in a liquid is greater than when in air. The scheme shows both ingenuity and novelty, but for the reasons already given we refrain from quoting any description.

The following chapter is devoted to the study of the measurement of velocity in which five distinct groups of tachometers are recognised and described: (*a*) centrifugal force; (*b*) chronometric action; (*c*) magnetic drag; (*d*) electrical similar to dynamo, and (*e*) viscous drag. In discussing forms of centrifugal instruments, the author insists on keeping the inertia of the moving parts as small as is consistent with sufficient power to actuate satisfactorily. It would have been well if this obvious conclusion had been discussed in reference to anemometers at fixed stations, but this class of instrument is treated very briefly. It is true that Robinson's anemometer is mentioned, but this is in connection with the measurement of the velocity of aircraft, and other forms of anemometer used in meteorology are not considered. The possibilities of the hot wire anemometer seem promising, but apparently the design has not passed beyond the experimental stage. The remarks on the determination of the velocity of projectiles, involving the instantaneous record of electrical impulses, have great popular interest.

The chapter on the measurement of force and the comparison of masses must be passed over, though one would have liked to have contrasted the delicacy exhibited in the construction of balances designed for the verification of fundamental normal weights, or for the determination of the mean density of the earth in Poynting's problem, with the weigh-bridges and platforms that play an important part in commerce and industry. It can only be said that the author exhibits here the same thoroughness and skilful handling that characterise the other chapters. In discussing the measurement of work, Mr. Griffiths comments, as others have before him, on the inadequacy and inconvenience of the term "horse-power." Against the use of the term "kilowatt" the same objections cannot be urged. Electrical engineers have grown recalcitrant and steps have been taken—may they prove efficacious—to remove the so-called horse-power entirely from the list of units of power. In another section of the same chapter, in treating of the possibility of using some electrical phenomenon, as the Piezo effect, for high speed indicators, we think the author is a little premature in claiming success for the use of the Piezo-electric properties of quartz in seismological registration. The promise of the possession of a system that is free from the inevitable defects of pendulum instruments is alluring, but the method has not been found suitable for the record of long waves of feeble energy, and moreover, practical difficulties have been experienced in the continual use of the instrument owing to the difficulty of sufficiently insulating the electrometer. The section of the book dealing with the testing of worm gear and the results that have been derived from recent experiment will repay careful study.

The last chapter is devoted to the measurement of temperature, a subject that has engrossed the attention of other members of the author's family, and perhaps for that reason some of the descriptions are rather curtailed. The concluding remarks on the precautions to be observed in using thermometers and pyrometers may be weighed and considered, for the caution they convey applies more or less to every instrument described here. "A pyrometer like every other tool or measuring instrument will only give reliable results when used intelligently and with due regard to its limitations." This may wear the appearance of emphasising the obvious, but it enunciates a truth which is so often overlooked that it may be repeated once again. It is as necessary to reform the undiscerning methods of the workman, as it is to improve his tools.

The Mechanical Principles of the Aeroplane. By Dr. S. Brodetsky. London: J. and A. Churchill. [Price 21*s.* net.]

It is useless to disguise the fact that, as a class, mathematicians, especially of the purer type, have acquired a bad reputation with engineers; but to admit this is not necessarily to assent to the implication, for it is equally true to say that engineers have acquired a bad reputation with mathematicians. The cause is not far to seek. Individual members of both classes frequently do not realise their own limitations and lack of equipment, and entering their neighbour's territory with all the assurance born of ignorance render themselves ridiculous by showing the others "how to do it." The pages of engineering journals are red with their battles.

It is unfortunate for the applied mathematician, the mathematical physicist or theoretical engineer, call him what you will, that his vocation is usurped by the pure mathematician on the one hand, and, by the practical engineer or physicist on the other, for he invariably becomes the scapegoat of both sides. His position is an extremely difficult one. Besides being a good mathematician capable of using all the most recent weapons forged by his "purer" colleagues, he must assimilate the experience and acquire the instinct of the experimental physicist and practical engineer. Otherwise how will he be able to discriminate intelligently in the neglect of this or that factor? How else is he to resist the temptation of making the physical world fit his mathematics, instead of discovering the mathematics to fit the physical world? Hence the scarcity of really first-class applied mathematicians, and hence also the unfortunate internecine war between two equally sincere searchers after truth. Each must realise that there is, and ought to be, a buffer state between them, and that for the self-respect and dignity of both sides the independent existence of the applied mathematician ought to be guaranteed. To the engineer he is a theorist, a dreamer; to the mathematician pure, if not simple, he is a man of action, and no doubt both are right. It is in the light of these remarks that the merit of the present book ought to be assessed, for it is professedly a work on a chapter of applied mathematics, albeit a new chapter. In criticising it from this standpoint it must, however, in justice, be admitted at once that the test is necessarily a severe one. It must bear analysis from the mathematical, from the physical and from the engineering points of view, and it is perhaps needless to remark that very few books exist that would suffer such scrutiny undamaged.

The immense and utterly unforeseen demands in aeronautics during the war afforded a unique opportunity to the engineer and the physicist of the experimental turn of mind, which neither was slow to seize. As a natural consequence the study of the subject on the experimental side made phenomenal strides, while, with a few honourable exceptions, the mathematicians were left panting far behind, not sure even whether to enter into the chase or not. The excitement and pressure over, it is now possible, in quieter mood, to survey the ground covered and take note of the vast fields untouched. Dr. Brodetsky was one of those few mathematicians who accepted the challenge thrown out by the new science and strove to face the problems raised, with the instruments at his disposal, and in many respects the present work must be taken as an index of his attitude to these questions. The book, which is separated into three sections, deals, in the first instance, with what is termed "motion in air," and is an exceptionally able treatment and application of the classical dynamics of the resisted motion of a particle and of a rigid body, to a parachute, a kite and an aeroplane. The mathematics, if at times intense, is thoroughly sound and well executed, and the exposition clear. Especially is this section to be commended for its interesting analysis of phugoids, interesting, that is to say, from the mathematical and the historical standpoints, for it illustrates and develops one of the earliest attempts by Lanchester at the solution of the motion of an aeroplane. From the practical point of view, however, the results can scarcely be considered of value, for, stripped of the language in which the assumptions are enveloped, it becomes clear that the problem considered deals with the motion of a particle of finite mass, and, of course, no moment of inertia, moving under no resisting force or thrust, but under gravity and a force perpendicular to its path and proportional to the square of the velocity.

In this same section of the book occurs a good chapter on that most fundamental subject, the Theory of Dimensions, a thorough understanding of which will be of the utmost value to a man whether he be a physicist or an engineer. The question may be treated with the simplest of mathematics, but its fundamental importance cannot, we are convinced, be thoroughly appreciated unless it be accompanied by full experimental illustrations. Unfortunately the author gives us none. He prefers to hold to symbols all through and finally by a premature discussion of resistance derivatives for small changes in motion, involving dazzling systems of equations, tends to spoil the effect of the earlier portions of the chapter. Much of the criticism that will be levelled against Section II of this work would undoubtedly have been met had the author linked up this, his first chapter, with an experimental discussion. We finish Section I with the feeling that we require some experimental check to determine how far from, or how close to, reality we are. The author gives us none.

Section II is entitled "Dynamics of the Air," but deals with the motion of a perfect fluid of the Eulerian and of the discontinuous types. We seek in vain for the dynamics of the air, which is nowhere to be found, and we are reluctantly driven to the conclusion that the author is satisfied that the motion of a perfect fluid is a close enough approximation to that of a real fluid for practical purposes. The impression is certainly conveyed, if not in so many words, that the real problem does not differ too widely from that propounded. Now, for the justification of the theorist it is exceedingly important that the exact status of the perfect fluid in relation to aerodynamics should be appreciated. In such a medium, all bodies are "stream-line"; there is no resistance to steady motion, turbulence does not arise in the wake of a body in motion; and generally it is evident that the perfect fluid is at best only a wild approximation, if any, to air. To refer to the dynamics of such a medium as the dynamics of air is a travesty. There is nevertheless a real utility in investigations of this nature. On the one hand, by the very divergence of their results from reality, they serve to emphasise, by contrast, the vital properties that constitute

those of a real fluid. Comparisons of calculated cases of a perfect fluid with experimental results for the corresponding cases of the flow of water and of air indicate that the very life of a fluid is its viscosity, and on viscosity applied mathematicians must focus their attention. On the other hand a study of the mathematical solutions of the equations of a flow of a perfect fluid, especially when it involves vorticity, may suggest methods from the mathematical standpoint of treating the more complicated equations of viscous flow. From these two angles at least, it seems to us, such investigations are justified, quite apart from any direct utility they may have in electrical and heat conduction, but it is certainly not justifiable to leave any doubt whatsoever that the results obtained are no approximation to the motion of a real fluid. After devoting two chapters to the perfect fluid, Dr. Brodetsky disposes of the real fluid with which he is actually concerned in three lines. Very little real progress has admittedly been made in the mathematical study of the question, but it is surely more reasonable to expect that such simple solvable questions, even for steady motion, as the flow of air in a channel, or in a pipe, should be presented to the budding applied mathematician than that space should be devoted in such a book to, say, the flow of a perfect fluid between the two branches of a hyperbolic cylinder (page 179). After all, aerodynamic and hydrodynamic experiments do take place in channels of rectangular and circular section. No reference can be found anywhere to a critical value for $\frac{v\,l}{\nu}$ the fundamental fact calling for explanation in any adequate understanding of the subject. It is not to be expected, of course, that the author would enter in detail into these questions, but from the point of view of mathematical physics it is essential that a clear understanding should be produced of how far the results obtained conform with fact and what fundamental ideas still require elucidation. There is no doubt that the omission of any discussion of the motion of real fluids is largely responsible for the feeling of artificiality produced on the mind by this section. In one of the few instances where a comparison is made between theory and experiment where the resistance of a plane calculated on the theory that the fluid in the wake of the plane is "dead," is plotted on the same diagram with actual experimental measurements of resistance (page 194), the source of the experimental results is not quoted, nor are any comments made on agreement or otherwise, in spite of the fact that, for the portion of the range of practical importance, the two results differ sometimes by as much as 100 per cent. as far as resistance is concerned! Later (page 217), referring to the same diagram, the author actually states that the agreement is sufficiently close to afford some confidence in both the basis of the theory and the methods of experiment! It would be interesting to hear the experimenter's opinion on this point of view. One is inevitably driven to the conclusion that the mathematical analysis is apparently of more interest to the author than the question as to whether it corresponds to reality or not. That Dr. Brodetsky is a mathematician of no mean order is obvious to anyone who reads this work, but it is not to the mathematical methods and detail that objection is raised, but to the cause of that strong sense of unreality produced on the reader. But it is not merely in its physics that this book shows weakness; it is weak in its analysis from the engineering standpoint. We take only one illustration. Performance, a sound discussion of which the engineer always seeks, finds no place in this book, while we venture to believe that in a work dealing with the mechanical principles of the aeroplane such a section of the subject would be inadequately dealt with, if a whole chapter were devoted to it. It is quite well adapted to mathematical and graphical analysis, and is the surest standpoint for investigating the interplay of the "useful" and the "wasteful" principles at work.

But while we have criticised, rather adversely, these sections of the book, it must be remembered that in many respects they deal with matters only partially amenable to mathematical treatment. It is only fair to contrast with these Section III dealing with stability and allied questions, where the subject lends itself almost at once to mathematical handling. Here the author is on surer ground, and it is dealt with very adequately. It is to this branch of the question that Dr. Brodetsky has contributed his original work, and it is well done. Unfortunately the older student of stability is asked to bear yet another burden in the shape of a new system of axes and new notation, differing from each of the systems previously in vogue in the Technical Reports of the Advisory Committee for Aeronautics and from those adopted later by the Technical Terms Committee of the Aeronautical Society. For ourselves we do not propose to judge between them. Provided each worker can understand his own system and convert his notation into whatever system is adopted as standard at the various research and test establishments, so that the data derived there may be of use to him, the position is sufficiently satisfactory, and this appears also to be the attitude of the author.

Aeronautics, in spite of the fact that as a science it is yet a child, has already acquired quite a voluminous library and literature, but, with very few exceptions, the books are intended pre-eminently for designers. The present volume is certainly not of that nature. It bears the clear imprint of the student text-book and is evidently intended as a guide to students of applied mathematics that they may recognise that in aeronautics and aerodynamics lies a fruitful field for theoretic investigation. In that the author has undoubtedly succeeded, but it does not follow, as we have striven to show, that he has himself produced a good treatment of the subject. As a book on a chapter of applied mathematics we believe it is weak; as a book on mathematical problems suggested by aeronautics, it is excellent.

Metallography. Part II. *Metals and Common Alloys.* By S. L. HOYT. New York and London: McGraw-Hill Book Company, Inc. [Price 28*s.* net.]

WITH the large number of books relating to the physical metallurgy of iron and steel which have been published in the last ten years it would seem naturally that the need for still another one might not be altogether obvious and might be regarded, in fact, with a quite understandable apathy. For this book, ostensibly supposed to deal with the metals and common alloys, is very largely taken up with iron and steel—no fewer than 316 pages out of 457 being devoted to this branch of the subject. But a glance through it is sufficient to show that it is one of the best, if not the very best, yet published. It will immediately take its place beside the elect on the bookshelves, amongst the few books to which one constantly refers.

The amount of information which it contains is immense, and nearly every statement of fact is accompanied by an accurate reference, so that for the student the path to wider fields lies straight before him. And yet this mass of information is treated broadly and critically, and is not marred by a one-sided presentation with the author always in the limelight, after the manner which has spoiled at least two recent books on similar subjects. Professor Hoyt has written an impartial survey of existing knowledge graced with real scholarship.

In the first chapter the physical properties of pure metals are given, together with full accounts of the variation of these properties with temperature for the more common metals. Iron receives extended treatment and the controversy regarding allotropy is given its full share of attention. Consideration is devoted in the next section to bearing metal alloys and prominence is given to the interesting work on these alloys which has been carried out in America with the object of replacing the tin base by lead. In place of the ordinary Babbitt metal, for all bearings working under normal pressure the Westinghouse Company are using exclusively a lead base alloy containing 78 per cent. lead, 14 per cent. antimony and 8 per cent. tin, with satisfactory results. This alloy at higher temperatures is decidedly harder than Babbitt and gives a better life.

Stating briefly the uses and properties of the light aluminium alloys, the author goes on to the consideration of brasses and bronzes, which he describes fully and in a succinct manner gives all the prominent facts concerning their theory and application.

The remainder of the book is devoted to the consideration of iron and steel, and is the most complete record of the physical properties which has yet been published in book form. The subject is treated from the point of view which has become defined only in recent years, that of the metallurgist keenly alive to all the refinements of physical measurement and adding to his sense of accuracy a knowledge of the chemical properties and impurities of his specimens, and an appreciation of their individual characteristics. Succeeding ages have one necessity in common, the necessity for subdivided specialisation, and the engineer is relying each day to a greater extent on the advice of the physical metallurgist in the choice of his materials of construction. It may therefore be conceded that this book is intended for the metallurgist rather than for the engineer, but there are few engineers who would not profit by reading it carefully, and all who do will find much pleasure in the task.

BOOKS RECEIVED.

Handbuch des Wasserbaues für das Studium und die Praxis. Vols. I and II. Von HUBERT ENGELS. Second edition. Leipzig: Wilhelm Engelmann. [Price 360 marks.]

Die Ausnutzung Der Wasserkräfte. Von E. MATTERN. Third edition. Leipzig: Wilhelm Engelmann. [Price 212 marks.]

Manual of Electrical Undertakings and Directory of Officials, 1920–1921. Compiled under the direction of EMILE GARCKE, M.I.E.E., F.S.S. London: Electrical Press, Limited. [Price 30*s.* net.]

Electric Motor Installations; Their Upkeep and Lay-out. Manchester: The Vulcan Boiler and General Insurance Company, Limited. [Price 2*s.* 6*d.* net.]

United States Geological Survey. Mineral Resources of the United States. No. I: 7. *Secondary Metals in* 1919. By J. P. DUNLOP. I: 8. *Chromite in* 1919. By J. S. DILLER. II: 9. *Mineral Waters in* 1919. By ARTHUR J. ELLIS. II: 11. *Gems and Precious Stones in* 1919. By B. H. STODDARD. II: 12. *Foreign Graphite in* 1919. By ARTHUR H. REDFIELD. Washington: Government Printing Office.

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A Dictionary of Applied Chemistry. Vol. II. *Calculi—Explosion.* By Sir EDWARD THORPE, C.B., LL.D., F.R.S. Revised and enlarged edition. London: Longmans, Green and Co. [Price 60*s.* net.]

Theory of Wave Transmission. A Treatise on Transmission of Power by Vibrations. Vol. I. By GEORGE CONSTANTINESCO. London: Proprietors of Patents Controlling Wave Transmission.

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Die Schwimmaufbereitung Der Erze. Von Dr. PAUL VAGELER. Dresden and Leipzig: Theodor Steinkopff. [Price 4*s.* 4*d.*]

United States Bureau of Mines. Bulletins No. 189. *Bibliography of Petroleum and Allied Substances in* 1918. By E. H. BURROUGHS. [Price 25 cents.] No. 191. *Quality of Gasoline Marketed in the United States.* By H. H. HILL and E. W. DEAN. [Price 30 cents.] Technical Papers No. 255. *Chlorination of Natural Gas.* By G. W. JONES, P. C. ALLISON and M. H. MEIGHAN. [Price 10 cents.] No. 275. *Quarry Accidents in the United States during the Calendar Year* 1919. By WM. W. ADAMS. [Price 10 cents.] Washington; Government Printing Office.

Modern Central Stations. Describing the Principal Features of Design, Construction and Operation in Modern Central Stations employing Steam Turbines. By CHARLES W. MARSHALL, B.Sc., A.M.I.E.E. London: Sir Isaac Pitman and Sons, Limited. [Price 2*s.* 6*d.* net.]

The Journal of the Institute of Metals. Vol. XXV. 1921. Edited by G. SHAW-SCOTT, M.Sc. London: Institute of Metals. [Price 31*s.* 6*d.* net.]

Thermionic Tubes in Radio Telegraphy and Telephony. By JOHN SCOTT-TAGGART. London: Wireless Press, Limited. [Price 25*s.* net.]

The Theory of the Induction Coil. By E. Taylor-Jones, D.Sc., F.Inst.P. London: Sir Isaac Pitman and Sons, Limited. [Price 12*s.* 6*d.* net.]

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Highway Engineering: Rural Roads and Pavements. By GEORGE R. CHATBURN, A.M., C.E. New York: John Wiley and Sons, Inc.; London: Chapman and Hall, Limited. [Price 18*s.* net.]

Proceedings of the Institution of Railway Signal Engineers, 1920. Manchester: H. Rawson and Co. [Price 5*s.*]

United States Coast and Geodetic Survey. Results of Observations made at the United States Coast and Geodetic Survey Magnetic Observatory near Honolulu, Hawaii, 1917 *and* 1918. By DANIEL L. HAZARD. [Price 25 cents.] *Results of Observations made at the United States Coast and Geodetic Survey Magnetic Observatory at Sitka, Alaska,* 1917 *and* 1918. By DANIEL L. HAZARD. [Price 45 cents.] Washington: Government Printing Office.

NITRIC ACID BY GAS EXPLOSIONS.

The chief processes for the fixation of atmospheric nitrogen either aim directly at the oxidation of the nitrogen to nitric oxide, to be converted into nitric acid, or they prepare in the first instance ammonia which is then oxidised catalytically to yield nitric acid. At present the latter indirect processes are technically of the greater importance. In the Haber process nitrogen and hydrogen are forced into combining with the aid of catalysts at relatively high temperatures and pressures. In the cyanamide (nitrolim) process of Caro and Frank calcium carbide is prepared and saturated with nitrogen to form cyanamide, which is used directly as a fertiliser or decomposed with water to liberate ammonia. Even if we regard ammonia as the final commercial product the two methods are not simple, considering that we have first to isolate the nitrogen from the atmosphere, which adds considerably to the cost of manufacture. The technical problem of the fixation of nitrogen is hence by no means regarded as solved, and novel methods are being investigated. Among these the process of Dr. F. Häusser, director of the Coal Technics Company (Kohlentechnik Gesellschaft), of Dortmund-Eving deserves attention, though operations in the small factory he built seem to have been discontinued for the present. Dr. Häusser renders the air explosive by adding some coal gas or producer gas to it, and it might be said that he obtains his nitric acid from the exhaust of an internal combustion engine. The process is described and illustrated in *Stahl und Eisen* of July 14 and 21 last; it was discussed in the Report of the Nitrogen Products Committee.*

Nitrogen and oxygen refuse to combine at ordinary temperature, at which nitrogen is very sluggish, but do combine at higher temperatures. The nitric oxide then formed decomposes again, however, unless rapidly cooled, and the technical difficulty of the oxidation is the removal of the NO from the hot atmosphere in which it is formed; that difficulty affects the nitrogen oxidation in the electric arc as well as in other processes. The sudden heating to high temperatures which takes place during explosions seemed to offer favourable conditions. In his first attempts Häusser mixed air with coal gas or carbon monoxide, condensed the mixture and exploded it in a bomb of a capacity of 1 litre or 3 litres (1 litre = 0·22 gallon), the same falling weight, which produced the ignition spark, opening also a valve which directed a jet of cold water into the bomb to quench the vapours. He found that the yield of NO increased with rising temperature and also with the increasing size of the bomb. In fact his yields were more than double those of Nernst's formula which assumes that the formation of NO is a purely thermal process. That this is not so, and that the electric phenomena play a part in arc processes has been shown by Haber and Koenig. Häusser's experiments also prove that the extrapolation of Nernst's figures to high temperatures is not permissible under his experimental conditions. Starting with a mixture of air and 25 per cent. of CO—15 per cent. of coal gas was used in other experiments—at a pressure of 3·5 atmospheres at ordinary temperature he obtained a gas containing 0·8 per cent. of NO by explosion at 23 atmospheres and 2,140 deg. C. absolute. That result was sufficiently encouraging for larger experiments with bombs of 100 litres and 300 litres capacity (100 litres = 35·3 cub. ft.) in a small factory, adjoining the De Wendel colliery which supplied the coke-oven gas.

In this factory the gas utilised is first freed of tar and ammonia, purified and stripped of benzol, and then sent through a meter into a compressor. The air is also compressed and passed through a heater coil placed in an exhaust-boiler referred to again below, so that it enters the bombs at 300 deg. C., and a pressure of 6 atmospheres. The experiments had suggested that the addition of oxygen to the air was advantageous. Further experiments proved that only little was gained by this addition, however, and the enrichment of the air with oxygen was hence abandoned. As soon as the bomb is charged, the gas is exploded by means of a Bosch magneto. The pressure rises to about 23 (22 to 25) atmospheres, and the exhaust valve is opened 0·15 sec. after ignition. Scavenging by slightly compressed air follows, and another ignition may take place after recharging; the bomb is fired 45 times per minute. The exhaust passes into a kind of marine boiler, in which the gases are cooled down to 250 deg. C.; the pre-heater coil alluded to for the air is at the far end of this boiler. From the boiler the gases are sent through an aluminium coil—the other parts so far mentioned are all of iron or steel, and they are not corroded by the gases—to the water separators and the towers in which the NO is oxidised to NO_2, and the NO_2 is absorbed by soda lye to yield nitrate and nitrite. The water collecting in the separators is almost free of acid, because owing to rapid cooling by the scavenging air, the NO is not oxidised until it arrives in the towers, and the NO itself is hardly soluble in water.

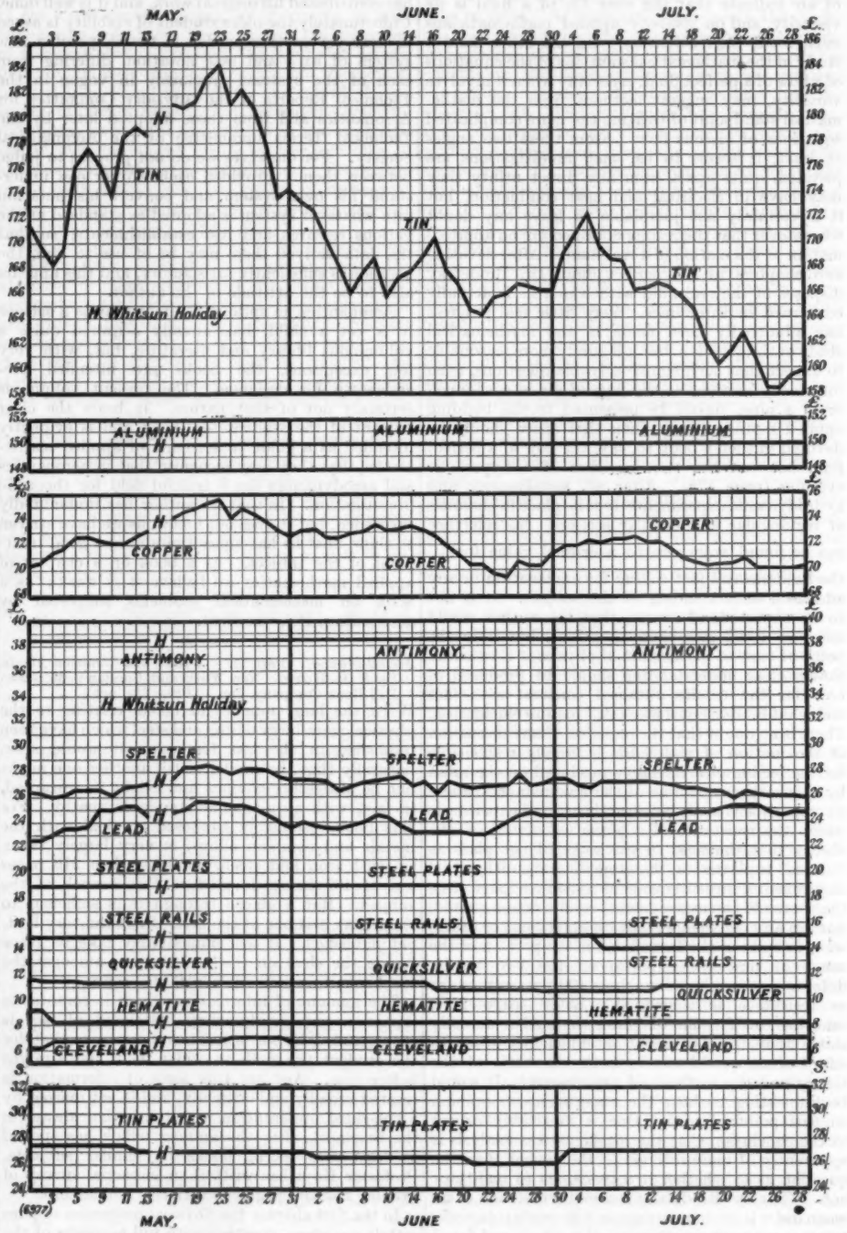
The valve gear is not illustrated in the article from which we quote. A sliding diaphragm is used to prevent the flame from striking back into the supply pipes. The use of this slide also cured pre-ignition troubles which at one time threatened to stop the experiments. Häusser was first rather pleasantly surprised that no pre-ignition occurred even when he added oxygen to his air and worked the bomb for eight hours continuously. Later, however, when he raised the initial compression above three atmospheres, pre-ignitions became a very serious source of trouble. They were finally traced down to an unsuitable packing material, and were prevented also by the adoption of the sliding diaphragm. The other part about which he was naturally anxious was the water-cooled exhaust valve. The cone of this valve has to be lifted against the full explosion pressure, and it is worked by an eccentric; cracks, indeed, developed in the valve seat in the course of a few weeks. Subsequently exhaust valves were constructed which lasted the continuous run of six months of the works in 1918. The practical experiments, we should say, were begun before the war; the experimental factory was ready by 1915, when Häusser was sent to the front.

In his second article Häusser discusses the possibilities of larger bombs, of 1,000 and 1,500 litres, which promise larger yields. He points out that the initial compression would not be required in colliery plants, where compressed air is available. But he does not refer to two main points. Any explosion of coal gas or CO yields CO_2, which is also absorbed by the soda, as well as by the water, and must cause trouble. Secondly, it seems wasteful to explode a quantity of gas merely to produce a little nitric acid, without utilising the explosive energy at all. If the latter could be done, and the process be modified so as to raise the general economy of collieries and gas works, matters would assume a very different aspect. Häusser in fact contemplated in his original patent of 1906 the employment of a gas engine for his process of fixing atmospheric nitrogen. The article in question only refers to stationary bombs, and he does not touch upon the power question, which indeed does not look hopeful.

* See ENGINEERING, January 23, 1920, page 119.

DIAGRAMS OF THREE MONTHS FLUCTUATIONS IN PRICES OF METALS.

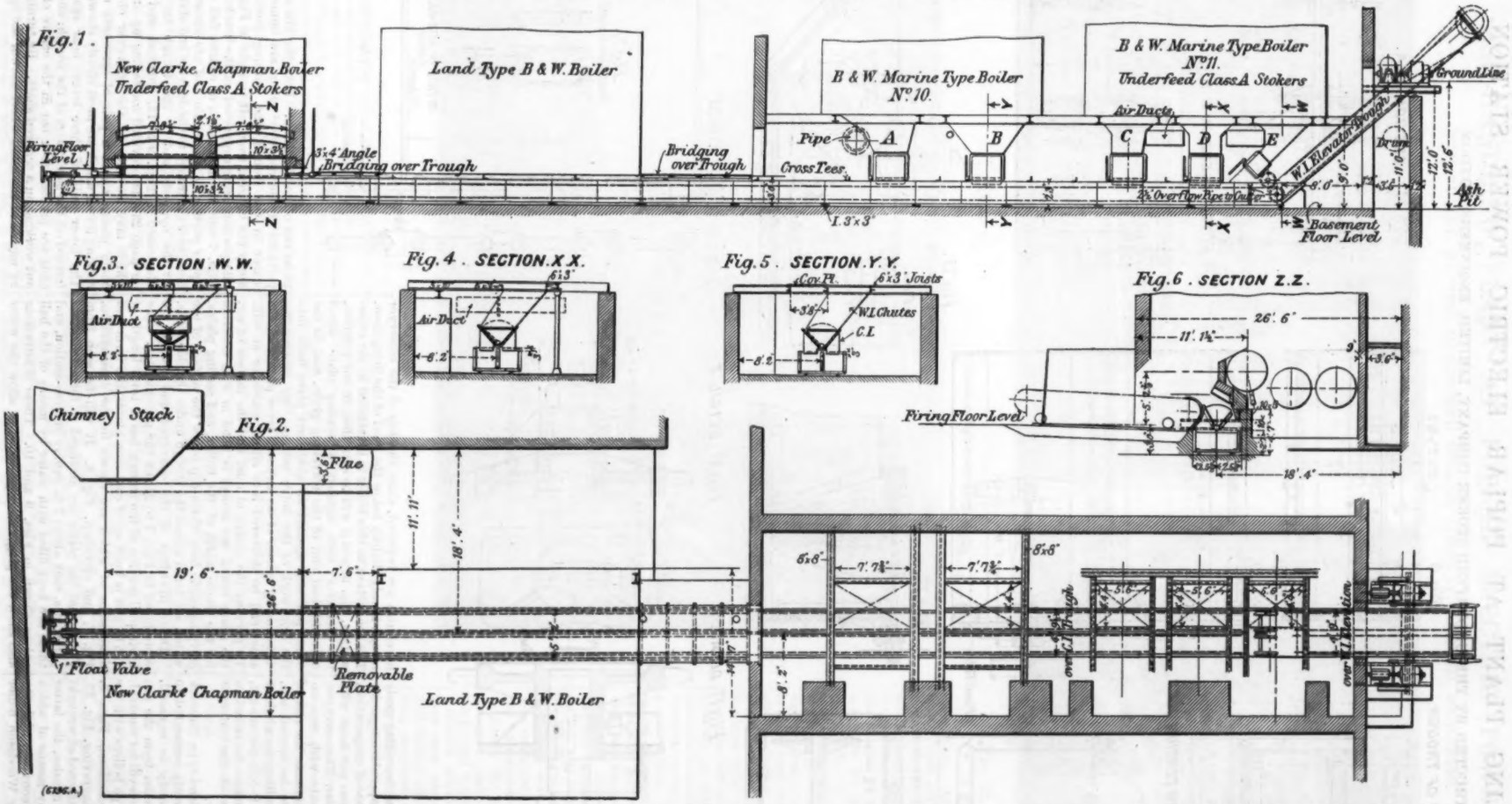
(Specially Compiled from Official Reports of London Metal Markets.)



NOTE.—In the diagrams the figures plotted for tin and copper are the official closing cash quotations of the London Metal Exchange for fine "foreign" and "standard" metal respectively. The prices shown for lead are for English metal, whilst those for spelter are for American metal. Middlesbrough prices are plotted for steel plates and rails, and also for hematite and Cleveland pig-iron. The prices given, in the case of steel plates are for ship, bridge and tank qualities, and those for steel rails are for heavy sections. The pig-iron prices are for the East Coast hematite and Cleveland iron, both of No. 1 quality and for home consumption. The price of tin-plates is per box of I.C. cokes f.o.b. at Welsh ports, but in all other cases the prices are per ton. Each vertical line in the diagram represents a market-day, and the horizontal lines represent 1*l.* each, except in the case of the diagram relating to tin-plates, where they represent 1*s.* each.

ASH-HANDLING PLANT AT POPLAR ELECTRIC POWER STATION.

CONSTRUCTED BY THE UNDERFEED STOKER COMPANY, LIMITED, ENGINEERS, LONDON.



By no means the least of the many difficulties experienced in the operation of boiler plants at the present time arise in connection with the method of handling and disposing of the ashes produced. Mechanical appliances for this work have, of course, been adopted in most large modern power plants, but the present high price and scarcity of coal and the consequent necessity for using lower-grade fuels containing larger percentages of ash, has now rendered their employment desirable in plants of more moderate capacities. The higher cost of unskilled labour also enables greater economies to be effected by dispensing with that commodity than was formerly the case, and this fact is a further inducement to power users to instal ash-conveying machinery to replace the employment of labourers and wheel barrows.

Labour saving was certainly an important consideration in connection with the installation of the ash-handling plant illustrated on the present page and also on pages 232 and 233. This plant was put into operation about six months ago at the Glaucus-street power station of the Poplar Borough Council, and has since been working to the complete satisfaction of the chief engineer, Mr. J. Horace Bowden, who has already ordered a further installation for the other side of the boiler house. It was designed and constructed by the Underfeed Stoker Company, Limited, Coventry House, South-place, London, E.C. 2, who own the patents for the system and who have carried out a number of similar installations at other power plants in different parts of the country. The detail arrangements of these installations naturally vary in accordance with the conditions to be complied with, but in each case the ashes and clinkers fall directly from the grate into a trough containing water, whence they are continuously removed by a drag-link conveyor. The ashes are thus instantly quenched, and masses of clinker are broken up into small particles by the sudden contact with the water—a fact which materially facilitates their removal. The lower end of the chute through which the ashes fall dips below the surface of the water, thus maintaining a perfect air seal in the combustion chamber at all times, and also preventing the escape of dust and fumes into the ash tunnel. It is not necessary, as might at first sight appear, for the boilers to be built above ground level, as the water trough can be arranged in the boiler setting, and it is quite possible to install the whole plant without diminishing the output from the boiler house. This, in fact, was done in the case of the Poplar installation we are about to describe.

The general arrangement of the plant is shown by the drawings reproduced on page 000, in which Figs. 1 and 2 are, respectively, an elevation and a plan, while Figs. 3 to 6 are cross-sections through planes indicated in Fig. 1. It will be seen that the conveyor handles the ashes from four boilers, that on the left being a Woodeson boiler by Messrs. Clarke, Chapman and Co., Limited, while adjoining this is a land-type Babcock and Wilcox boiler; both these boilers are mounted on the ground level. The other two boilers are of the Babcock and Wilcox marine type, and these are mounted on girders 9 ft. above ground level, with an ash tunnel underneath. The four boilers, all of

ASH-HANDLING PLANT AT POPLAR ELECTRIC POWER STATION.

CONSTRUCTED BY THE UNDERFEED STOKER COMPANY, LIMITED, ENGINEERS, LONDON.

Fig. 7. GENERAL SECTION OF TROUGH.

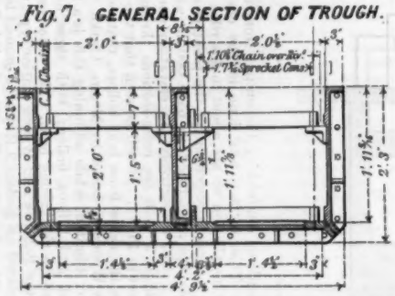


Fig. 8.

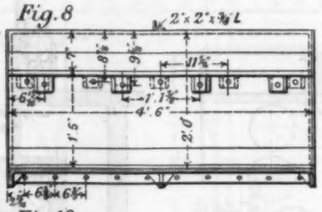


Fig. 14. SECTION A.A.

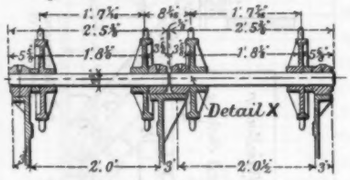


Fig. 9. END OF TROUGH WITH TENSION GEAR.

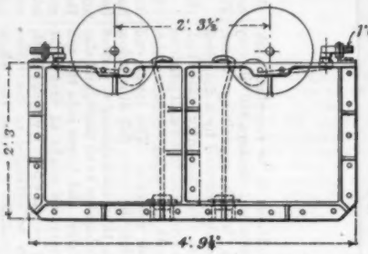


Fig. 10.

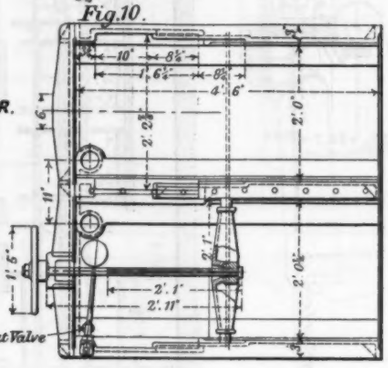


Fig. 15. SECTION B.B.

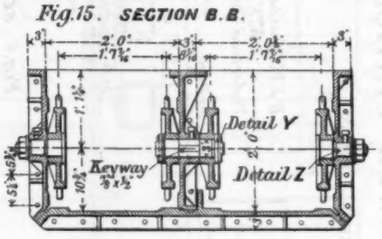


Fig. 11.

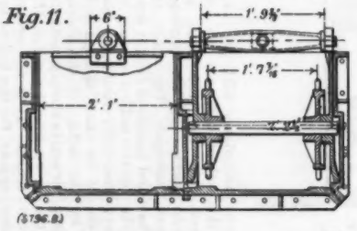


Fig. 12.

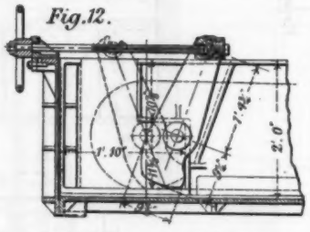


Fig. 13.

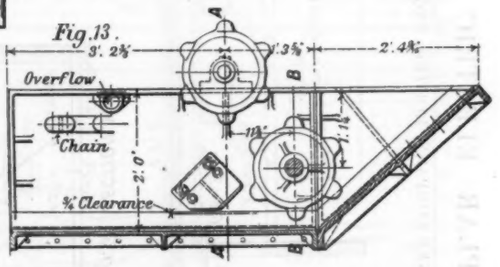


Fig. 16. DETAIL X.

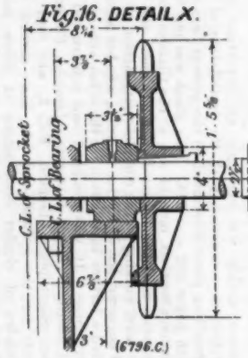


Fig. 17. DETAIL Y.

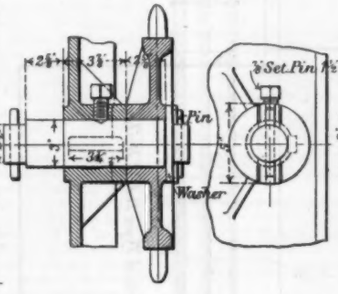


Fig. 18. DETAIL Z.

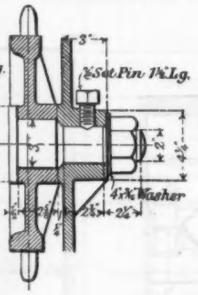


Fig. 19.

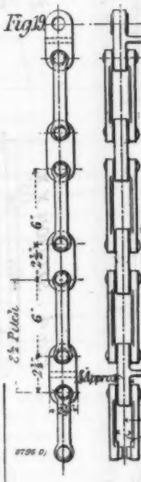


Fig. 20.

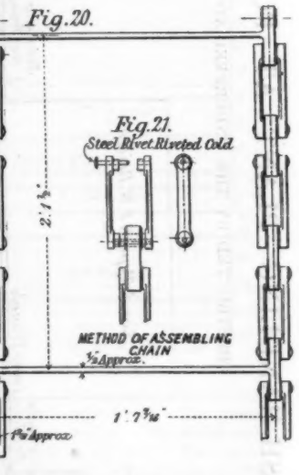


Fig. 21.

which are fitted with stokers of the travelling grate type, have an aggregate maximum evaporative capacity of 145,000 lb. per hour, and at this rate of evaporation, the ash production amounts to 4½ tons per hour with the quality of coal now in use at Poplar. The conveyor, which has been installed in duplicate with two independent sets of driving gear to eliminate the risk of breakdown and to enable repairs to be carried out, has proved itself easily capable of handling the whole of the ashes produced when running at 9·5 ft. per minute, but this speed could, without detriment, be raised to 20 ft. per minute and the capacity of the conveyor proportionally increased if necessary.

It should be explained that the land-type Babcock and Wilcox boiler has not been directly connected to the ash conveyor, since it will shortly be replaced, the ashes in the meantime being taken from the ash pit by hand and tipped into the conveyor for removal. The chutes connecting the marine-type boilers with the conveyor are shown in the cross-sections, Figs. 3, 4 and 5 and also in the half-tone engraving, Fig. 23, on page 233. These chutes are constructed of wrought iron plates with cast-iron discharge nozzles, the latter being fitted with deflecting plates by means of which the ashes can be diverted into either conveyor while the other is at rest. In the case of the Woodeson boiler no chutes are required, since the top of the conveyor trough is only slightly below the level of the firing floor. The connection to this boiler is illustrated in the cross-section, Fig. 6, and it will be seen that, in one position, the deflector rests against a sealing plate fitted over the rear end of the travelling grate, and, in the other position, against an abutment plate built into the brickwork of the boiler setting. By moving the deflector by means of an external lever provided, the ashes can be delivered into either conveyor at will. To prevent the escape of dust and the ingress of air, the space round the trough is filled in with concrete for the whole width of the boiler, and sealing plates, carrying angle bars which dip below the surface of the water, are fitted across the trough under the side walls.

Detail drawings of the conveyor and trough are reproduced in Figs. 7 to 21, on the present page. The horizontal portion of the trough has a total length of 125 ft. and is built up of cast-iron plates, the form and dimensions of which are shown in the cross-section, Fig. 7, and elevation, Fig. 8. It will be seen from Fig. 7 that the plates are arranged to form two compartments, each about 2 ft. square in cross-section, and these are kept filled with water by means of the ball valves shown in Figs. 9 and 10. These illustrations also show the plug valves provided to allow the water to be run off to the drain. Both the idle and working portions of the conveyor chain are immersed in the water in the trough, the working portion running along the bottom, from left to right in Fig. 1, and the idle portion being supported on the brackets shown in Figs. 7 and 8. The ashes, of course, fall through the upper portion of the chain and are drawn along the bottom of the trough to the delivery end of the conveyor. At the opposite end of the trough the mechanism illustrated in Figs. 9 to 12, annexed, and in Fig. 22, on page 233, is provided for taking up any slackness which may develop in the conveyor chains. Each chain passes round a pair of sprockets mounted on rocking levers which are most clearly shown in Fig. 12. The lower ends of these levers bear against flanges formed on the side plates of the trough, and the upper ends are pivoted to a bar in the centre of which is a nut working on a screwed shaft. By turning this shaft by means of the hand wheel shown, the sprockets can

ASH-HANDLING PLANT AT POPLAR ELECTRIC POWER STATION.

CONSTRUCTED BY THE UNDERFEED STOKER COMPANY, LIMITED, ENGINEERS, LONDON.

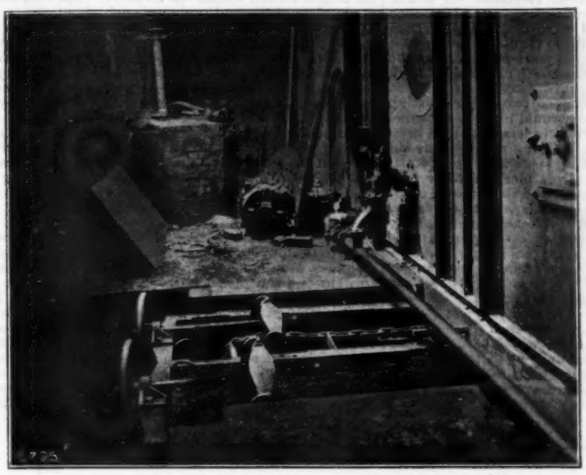


Fig. 22.

Fig. 23.

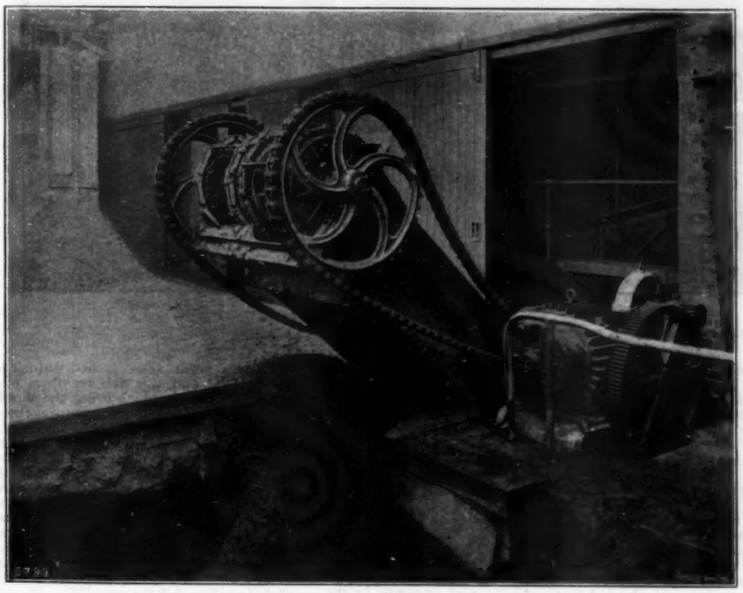


Fig. 24.

be drawn towards the end of the trough to tighten the chain, as will be obvious from the figures.

At the delivery end of the conveyor the horizontal cast-iron trough is connected to an inclined elevator trough constructed of wrought iron plates and shown in Fig. 1. At the lower end of the inclined trough, guide sprockets are fitted to change the direction of the conveyor chains. The general arrangement of these sprockets is shown in Figs. 13, 14 and 15, while details of the bearings are illustrated, to a larger scale, in Figs. 16, 17 and 18. As the ashes are drawn up the trough the greater part of the water drains back, so that they leave from the upper end in a comparatively dry state. It should here be explained that, owing to lack of space, the inclination of the elevator trough, which is 41 deg. in this particular installation, had to be made rather greater than is considered generally desirable, but no difficulty in working has arisen from this cause. A special arrangement for one of the ash chutes from the right-hand boiler in Fig. 1 had to be adopted owing to the bend in the conveyor at this point, and the constructional difficulties were somewhat augmented by the presence of hot-air ducts under this boiler. The nozzle of this chute was therefore arranged to deliver the ashes at an angle of 45 deg. to the direction of the conveyor, as shown in Figs. 1 and 3, instead of at right angles to it.

The type of conveyor chain used is illustrated in Figs. 19, 20 and 21, and is similar to that largely employed for hot-coke conveyors in gas works. It is composed of drop-forged steel links, connected by steel rivets, but it should be noted that neither the shear nor the wear comes on the rivets, but on bosses formed on the links themselves. To allow more material for wear without undue weakening of the chain, the rivets are eccentric with the bosses, as shown in Fig. 21. The pitch of the chain is 8½ in. and the spacing between the scraper plates, which are of cast steel, is 2 ft. 1½ in.; this, of course, is sufficient to allow large masses of clinker to fall through the upper portion of the chain. The breaking load for the complete conveyor is 19 tons.

A photograph of the delivery end of the conveyor, showing the driving arrangements, is reproduced in Fig. 24, above. Each conveyor is driven independently by an electric motor through worm and spur reduction gearing and a roller chain. With one conveyor running at 9·5 ft. per minute and handling 3½ tons of ashes per hour, which is the quantity produced under normal working conditions, the current consumption amounts to 6¼ amperes at 220 volts, or under 2 h.p. As will be seen from Fig. 24, the ashes fall into an open pit, and from this they are removed by a grab bucket worked from an overhead runway. The ashes, it may be remarked, are delivered in a finely-divided state, the average size of the particles being about equal to that of a pea. They thus form a good aggregate for breeze concrete without any further treatment.

As previously mentioned, the plant has now been working satisfactorily for over six months, and no signs of wear or corrosion are yet apparent. Corrosion, in fact, need not be feared since the water becomes alkaline rather than acid. In some tests made at Poplar, the water, before use, was found to have a hardness of 30·88 deg., and after being used for two days the hardness had increased to 58·95 deg. The quantity of make-up water required by the system amounts to about 40 per cent. of the weight of the ashes handled, or, say, 90 gallons per ton, so that this is not a serious item. Other advantages claimed for the wet conveyor system of ash handling are that there is no storage of hot materials, and no crushing machinery, such as is required when the ashes are handled by the pneumatic system, is needed. The power required, and the attention necessary, for operating the latter system are also much greater than for the former. To handle pneumatically the same quantity of ashes as is dealt with by the plant above described, it has been estimated that a crusher driven by a 6-h.p. motor, and an exhauster absorbing about 60 h.p., would be required; the normal power consumption of the wet conveyor plant, as previously mentioned, is only 2 h.p., and it needs very little attention.

Several alternative arrangements of the conveyor have been adopted in other installations to comply with special conditions. In some cases the trough has been mounted above ground level with the chain returning underneath in the dry, and in other cases a single conveyor, with provision for handling the ashes by hand in the event of a stoppage, has been employed. In the latter arrangement auxiliary outlets are provided on the ash chutes under which a barrow or wagon can be placed to enable the ashes to be wheeled away. It may also prove more economical, in some cases, to form the trough in concrete with cast-iron rubbing plates in the bottom. We need hardly add, in conclusion, that the system can be employed for handling the ashes from metallurgical and other industrial furnaces fired with solid fuel, as well as from steam boilers.

The Swedish Spitzbergen Coal-Mining Company.—We read in *Swedish Export* that the Riksdag has assented to the proposal of the Committee of Ways and Means that the Swedish Spitzbergen Coal Company should be granted a subvention in the form of taking up shares in the company to an amount of 2,000,000 kronor, of which 1·25 million kronor are to be subscribed immediately and 750,000 kronor after some time has elapsed, providing that the conditions in the coal market are in favour of the company being able to dispose of their products. This subvention will be the means of keeping the Spitzbergen coal deposits in Swedish possession, as otherwise the company would have been compelled to consider offers from foreign purchasers.

VERTICAL LIFT BRIDGES.*

By Ernest E. Howard, M.Am.Soc.C.E.

(*Continued from page 202.*)

Part III.—A Bridge with a Lifting Deck.

The North Kansas City Bridge over the Missouri River.—The Union Depot and Terminal Railway Company's bridge over the Missouri River at Kansas City, Mo., called the North Kansas City Bridge, was completed in 1912 at a cost of 2,400,000 dols. It is a double-deck structure (Fig. 4). The lower deck extends across the river only, a distance of 1,280 ft., and carries a standard double-track railway. The upper deck provides double track for electric cars in a central roadway which also serves fast motor vehicles, two side roadways and two sidewalks from the south end of the bridge to the north side of the river, where stairs give access to the ground. The length between the ends of the upper deck approaches is 5,340 ft.

The main, or river, portion of the bridge consists of three heavy riveted truss spans each 428 ft. long. Two of these spans carry the highway deck at the top chord and the railway deck at the bottom chord. The third span is placed at a higher elevation so that its lower chords are just below the upper deck. The railway deck of this span is suspended from the main trusses and can be raised to permit the passage of boats. The navigable channel is 412 ft. wide between piers and, with lower deck raised, has a vertical clearance of 65 ft. above standard high water.

The southerly approach to the river bridge is 1,630 ft. long, consisting of 1,156 ft. of steel viaduct and spans and 474 ft. of earth embankment. The northerly approach is 2,428 ft. long, with 1,708 ft. of steel viaduct and spans, and 720 ft. of embankments. The railway tracks on the lower deck of the river spans curve out under the approach viaducts at each side of the river.

Approximate Quantities.—The following tabulation of the quantities for the North Kansas City Bridge shows the approximate total superstructure metal, piling and substructure masonry required :—

Superstructure metal :	
South approach viaduct ...	885 tons
South approach spans ...	1,617 tons
North approach viaduct ...	2,460 tons
North approach spans ...	236 tons
Two fixed spans	8,037 tons
Lift span—	
Carbon steel	4,203 tons
Nickel steel	346 tons
Machinery	292 tons
Total superstructure metal	18,076 tons
Side roadways	13,500 sq. yd.
Sidewalk	2,100 sq. yd.
Counterweights	380 cub. yd.
Substructure masonry, total	29,000 cub. yd.
Timber piles, 336	13,500 lin. ft.
Concrete piles (Chenoweth), 1,395	38,600 lin. ft.
Creosoted timber	950,000 ft. B.M.
Untreated timber	250,000 ft. B.M.

Confronting Conditions.—In the early 'nineties a high-level, single-deck railway and highway bridge was projected at this site and the piers were built, but lack of funds suspended further construction. The river was wider than at present, and the bridge was to include four main spans of 428 ft., and approaches. The property finally came into the possession of the present owners as part of large holdings on both sides of the river. Harbour lines were established by the Government, and extensive reclamation work confined the river to about three-fourths of its former width. Plans for the present bridge were started in 1907.

The new conditions required not only a high-level deck, with approaches over the tracks on both sides of the river, to accommodate highway traffic and street and inter-urban cars from St. Joseph, Excelsior Springs, and other points north of the river, but also a double-track railway deck at the level of the river valley to connect the terminal holdings of the company. This made necessary some kind of movable span, because a fixed bridge which would provide for the lower level tracks would not afford vertical clearance for boats. The original piers were well built of excellent limestone masonry laid in cement, and were in good condition. They rest on bed-rock 50 ft. to 60 ft. below low water. Originally built with starlings, they are 46 ft. long at the water level, thus sufficing for the width of a double-track bridge.

To construct a pivot pier between two of the existing piers for an ordinary swing span would limit the channel openings to about 160 ft., which is less than has been required for any swing span built in recent years on this river. To construct a swing span with two 200-ft. channels involved not only a pivot pier and draw protection, but also one new end pier, and the removal of an existing pier. The resulting short span in the river would have been uneconomical and somewhat unsightly. A bascule for such a wide opening could not be considered. Other possibilities were the lifting span or lifting deck. The lifting deck span offered a fixed upper roadway with uninterrupted highway and street-car travel, and involved only slight changes in the existing substructure. It appeared to be nearly 200,000 dols. less costly than a bridge with a swing span of the necessary length. The lifting deck idea also was adapted, without material alteration, to an uncertainty as to the ultimate future elevation of the lower deck railway tracks. Although for the immediate development a track elevation 24 ft. above high water was suitable, there was a possibility that an elevation perhaps 13 ft. higher might be necessary.

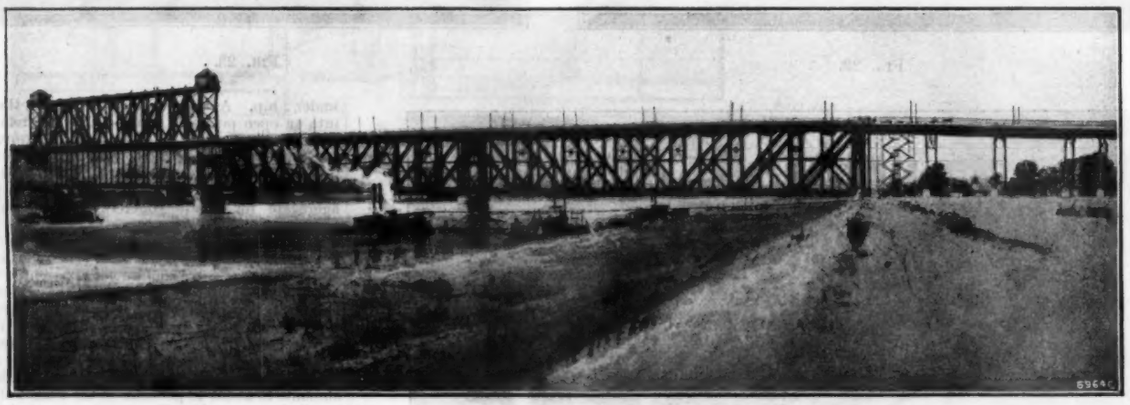


Fig. 4. General View of North Kansas City Bridge from Down Stream.

Loads and Working Stresses.—The live loads and impact assumed in the design were : For railways, Cooper's Class E. 50 ; for street railways, a continuous line of 50-ton cars and 30-ton special trucks ; for roadways, a 15-ton road roller or truck, and varying floor loads. Percentages for impact were added in all cases. The total live and impact loads on two trusses of a 423-ft. span, were 19,100 lb. per linear foot.

The unit stresses used in the design correspond closely to those specified by the American Railway Engineering Association, as follows : For nickel steel, 20,000 lb. per square inch in tension, with other working stresses to correspond ; for reinforced concrete in compression, 650 lb. per square inch ; and for tension in steel, 15,000 lb. per square inch ; load per mile, 27 tons ; load on bed-rock, 8·6 tons per square foot, maximum.

Substructure.—The four existing river piers were cut down to below the old starlings, and were capped with concrete copings 8 ft. thick. The other old piers were used almost without alteration, their shortness being compensated for by cross-girders long enough to extend out to the truss shoes of the span supported.

The approach viaducts rest on concrete pedestals supported on concrete piles, and in part on timber piles. The concrete piles were 33 ft. long, pre-cast, of the Chenoweth type, and were jetted and driven. The cost of remodelling the old substructure and building the new one was about 135,000 dols. The old piers cost when built about 600,000 dols.

Superstructure.—The river spans are of riveted construction ; two are exactly alike and the third is somewhat similar. The trusses, which are 32 ft., centres transversely, have parallel chords, sub-diagonals and hangers. The floors are of the usual character with wooden cross-ties for the tracks ; for the upper roadway the ties are double-planked. Cantilevers beyond the trusses, at the upper deck, support at each side a reinforced concrete slab on longitudinal stringers, comprising a roadway 13 ft. 6 in wide and a narrow sidewalk. These side roadways are paved with asphalt.

The chords are 5 ft. deep and the top chord cover-plate is 5 ft. wide. The maximum gross section of chord and end post is about 500 sq. in. Gusset plates are spliced into web-plates of members, with rivets in double shear wherever possible, thus making the gusset plates of minimum size and limiting the secondary stresses in the members. Even with these shingled gusset plates the main members were more than 16 ft. high above the rails when loaded for shipment, and closely approached the maximum size which could be shipped. The lacing on the open sides is of substantial angles connected by four rivets at each end to small lateral plates, with the angles turned within the member. The mid-sections of chords and the end posts are each about 100 ft. long, and weigh from 96 tons to 106 tons each.

The clearance for gusset plates was ¼ in., requiring nicety of shop work and ability in erection to insert members of such size and weight between gusset plates for distances of from 12 ft. to 16 ft. Where the grip exceeded 5 in., the rivets were coned to make upsetting easier.

Instead of the usual pin plates and shoe-pin at the ends of the trusses, cast steel diaphragms were riveted between the gusset plates. The lower end of the casting and the shoe below both afford full-length bearing for a 12-in. pin, which carries a total reaction of 2,400 tons, but is not subjected either to shear or bending.

Secondary Stresses.—The secondary stresses in main truss members were calculated and means used to reduce them to the lowest practicable limit. In general, the truss members were fabricated of lengths so that all would be straight and the chords horizontal when the whole truss carries full dead and one-half live and impact loads. The main diagonals and main posts, however, are straight under their own maximum conditions of similar loading. To reduce the secondary stresses due to chord stiffness, the chords were assembled on the ground in straight lines and the field splices reamed. When erected on the falsework the chords were again assembled in straight lines and the splices fitted up with full-sized bolts and pins. The chords were then jacked into cambered position for no load and the web members connected and riveted. Under loads which bring the chords down to horizontal, the secondary stresses are therefore minimum.

By an arrangement with Dr. W. S. Stratton, director of the United States Bureau of Standards, an effort was made to obtain direct measurement of actual stress distribution. Before erection, fixed points were set about 16 in. apart on several members, and micrometer gauge readings were made of the exact lengths, with due regard for temperature and other conditions. Corresponding readings were made after erection, and the comparison gave some indication of the amount and distribution of stresses, but the work has not been fully completed or classified for use.

Lifting Deck Span.—The lifting deck span is supported on two bents (Fig. 5) about 60 ft. high, with lateral bracing between columns. The columns are fixed transversely at their lower ends by anchor bolts which connect to heavy girders embedded in the piers. The supporting bent at one end of the span is part of a viaduct tower and provides a fixed end. The bent at the expansion end is a rocker pivoted on pins above and below.

The lifting deck of this span is an ordinary double-track railway bridge deck with four lines of continuous stringers riveted into cross floor-beams, with a lower lateral system and bottom chords. Each floor beam is suspended from the truss above by two stiff member hangers that rise into the truss spots above them when the deck is lifted. When in position for train traffic, the ends of the lifting deck rest in shoes on the piers, and all wind and vibration stresses are carried through the lateral system directly to the masonry. The vertical live loads on the lower deck are transmitted to the trusses of the supporting span through pins in the tops of the hangers which set in sockets on pairs of diaphragms in the truss posts.

The dead load on each hanger is taken by two 1½-in. wire ropes which pass up through the truss posts, over an idler sheave on the top chord, thence to the nearest adjacent corner of the span, where they pass over a grooved drum which accommodates one-fourth of all the suspending ropes, thence downward, and connect to a concrete counterweight. At the ends of the lifting deck no hangers are used, but the ropes extend down and

* Paper read before the American Society of Civil Engineers, May 4, 1921.

connect to the end floor beams. The corner drums are so grooved and so placed that the suspending ropes above the top chords diverge at slight angles so that each pair just clears the sheave at the next panel point. Leaving these corner drums the ropes again fan out so that they meet a row of deflecting sheaves at the upper

Operation by Corner Drums.—Operation is effected by rotating the upper corner drums, for the friction of the suspending ropes on them is sufficient to raise and lower the deck. The drums at each end are on a common shaft and so connect through a train of gears to an electric motor. Mechanical synchronisation of machinery at

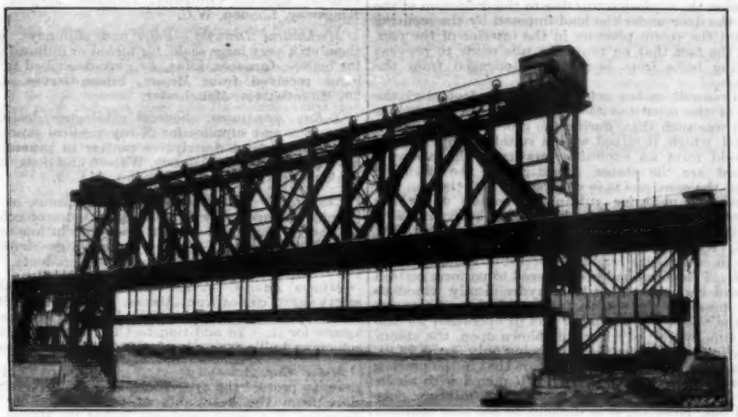


FIG. 5. NORTH KANSAS CITY BRIDGE: LIFTING DECK PARTLY RAISED.

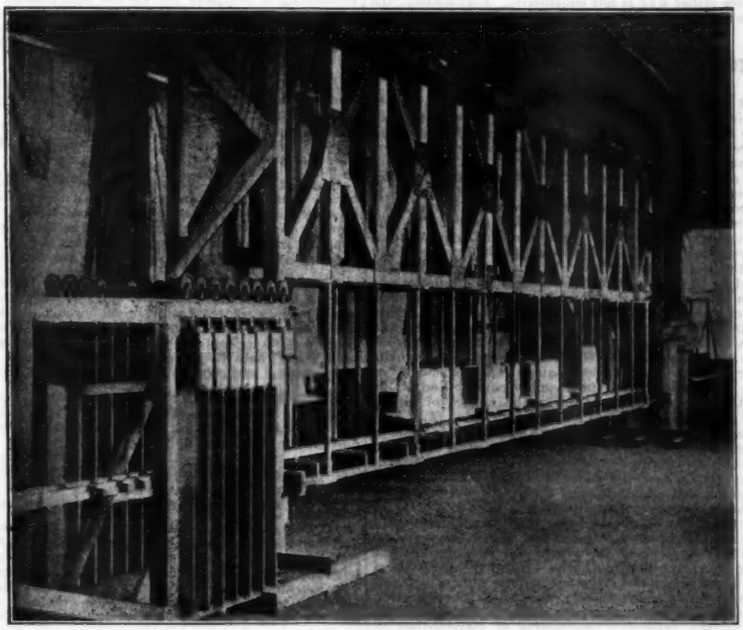


FIG. 6. MODEL OF LIFT SPAN, NORTH KANSAS CITY BRIDGE, SHOWING DECK DOWN AND LOAD ON DECK.

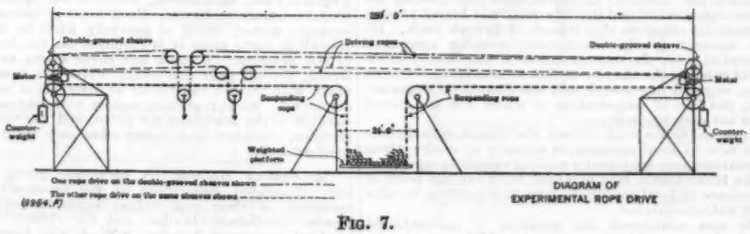


FIG. 7.

deck level in a line 3 ft. 7 in. outside the centre line of the trusses. The side lead of the ropes does not exceed ½ in. per foot.

Each floor beam dead load is thus balanced by two counterweights. These counterweights hang in four groups, in rows just outside the planes of the trusses, on both sides. Each counterweight has small jaw guides which engage on vertical tracks of Z-bars attached to the tower bracing or truss members. The lifting deck is thus counterbalanced by 32 counterweights of separate concrete blocks.

opposite ends, insuring consequent uniform movement of all points of the lifting deck, is secured by two counterweighted rope drives connecting opposite motor shafts. One rope drive has the taut line for driving in one direction, and the other has the taut line for the reverse. The motors are also connected electrically, and under ordinary conditions both operate simultaneously. In case either should be out of service the lifting deck can be operated by a single motor from either end, the machinery at the opposite end being operated through the rope drive.

The lifting deck is guided in its movement by jaw castings at its four corners, attached to the lower chords, which move astride angles on the main columns. Near their lower ends these vertical guides flare out slightly and bring the deck to exact lateral position as it approaches its seat. No other guides are used. The hangers are so much smaller than the truss posts that with maximum deflection they cannot come into contact, and they hang wholly free. When the lifting deck is down ready for train service it is locked in position by end locks on the piers and by locks at the top of each hanger. All these locks are drawn simultaneously at will, but each automatically and independently locks as the lifting deck comes to its seat, each lock having an operating counterweight. The function of the hanger locks is to overcome the slight lifting tendency of the continuous stringers under an advancing load. They consist of pairs of cams swinging on shafts in the posts so as to bear against seat castings on the hangers.

Motor-operated machinery, located in one of the machinery houses, draws the locks. It lifts all the counterweights over the neutral points so that each may be tripped and will then fall and throw its lock. All locks have electric contacts causing signal lamps to glow when the locks are withdrawn.

The lifting deck is operated by two railway type motors in series parallel, equipped with solenoid brakes. Magnet type controllers are used. Limit switches in emergency cut off the current and apply the brakes near each limit of movement. An indicator in the house shows the position of the lifting deck.

To save weight, the lifting deck and hangers are of nickel steel. The total load lifted is 800 tons, and the total moving load is about 1,700 tons. The maximum movement is 50 ft., which is traversed in less than 1 minute.

There is much duplication in machinery parts. Practically all deflecting sheaves are of one pattern. The operating drums are alike and the operating machinery at the ends is in duplicate. A concrete and steel house encloses the machinery at each end.

Manufacture and Erection.—Except for the 346 tons of nickel steel in the lifting deck and hangers, the bridge is of medium, open-hearth carbon steel, of substantially manufacturers' standard structural grade. The nickel steel has an ultimate strength of from 85,000 lb. to 100,000 lb., a minimum elastic limit of 50,000 lb., and is 3·25 per cent. nickel.

The shop work was excellent. So accurately were abutting ends of chords milled that the blade of a pen-knife could find no entrance around the entire perimeter of these members 5 ft. square. All rivet holes were sub-punched and reamed or drilled. Those for important field connections were reamed or drilled with the members assembled. This reaming and drilling of field holes for the main trusses was done near the bridge site where yard space nearly ¼ mile long was used for laying out the trusses.

The river spans were erected on pile falsework with an overhead steel traveller equipped with electric hoists. For the lifting deck span, framed bents in two lifts were built on the pile bents, so that the total height of the falsework above the river bed was about 120 ft. The larger members were lifted with special clamps which gave direct connection to the pins of the blocks.

The lifting deck was erected in raised position about 12 ft. below its upper limit, supported on temporary pins in special pin holes in the hangers. The concrete counterweights were built on the ground or on stagings below their respective positions, and after the suspending ropes had been laid in place and connected to the deck, were raised and attached to the ropes. The lifting deck was then raised slightly by the operating machinery and the temporary pins were removed.

Personnel and Prices.—The foundations, as originally constructed, were designed by Mr. Frank B. Moore. The new work was designed and construction supervised by the writer's then firm, Waddell and Harrington. The principal work, that of manufacture and erection of the superstructure, was in the hands of the McClintic-Marshall Construction Company. The late Paul K. Wolfel, M.Am.Soc.C.E., chief engineer of that company, made many valuable suggestions concerning the design, manufacture and erection of the large riveted spans. Much credit is also due to Mr. F. W. Pratt, an engineer of wide experience, then president of the Union Depot Bridge and Terminal Company. Work began in 1909, and the bridge was opened to traffic early in 1912.

The principal prices per pound for the superstructure were: Carbon steel for the viaduct on tangent, delivered 2·55 cents, erection 0·5 cents. per lb.; for the viaduct on curve, correspondingly, 2·6 cents. and 0·5 cents; for the main river spans, correspondingly, 2·76 cents and 1·125 cents; for nickel steel, delivered, 4·7 cents; erection 1·185 cents; for machinery, correspondingly 6·9 cents and 1·25 cents; for wire rope, 14 cents. The total cost of providing the lifting deck was 125,000 dols. more than the cost of a bridge of fixed simple spans throughout.

Model Demonstration prior to Construction.—In order to demonstrate to certain of the owners who could not wholly visualise the methods of operation from the drawings, a complete model of the movable span was built. (Fig. 6.) It was made to a scale of 1 : 15, so that the span length was 28 ft. 7 in., and the distance between truss centres was 25½ in. The members were of wood about 4 in. square, fastened together with steel gusset plates. Machinery was built conforming in every essential part to that proposed for the bridge, and electric motors and drives were installed and connected in the same manner with duplicate rope drives. The lifting deck was made to weigh one one-thousandth of the deck as built. Proportionate train loads were run over the deck. The model operated satisfactorily, and gave a perfect

demonstration of the proposed methods. Its construction cost was 1,500 dols.

Rope-Drive Experiments.—To meet criticisms of the proposed rope drives made by certain manufacturers of rope-driving machinery, a physical demonstration was arranged (Fig. 7). Driving machinery similar to that on the bridge, but with a sheave for a single suspending rope instead of drums, was placed on two platforms, 320 ft. apart. Each driver was operated by a 50-h.p. motor, which was also partly loaded by a brake. The two drivers were connected by a double rope drive. A loaded platform 24 ft. long was suspended midway between drivers, within a framework, by suspending ropes which extended over the sheaves on the drivers and connected to two counterweights composed of two cast-iron pile hammers. This suspended span was raised and lowered through 16 ft. without the slightest deviation of movement, as between ends, when operated by both motors or by either motor from either end, demonstrating the synchronism afforded by the rope drives.

A committee of engineers, consisting of Thomas E. Brown, M.Am.Soc.C.E.; Professor W. F. M. Goss, of the University of Illinois, Past-President, Am.Soc.M.E.; S. B. Fisher, M.Am.Soc.C.E., the chief engineer of the Missouri, Kansas and Texas Railway Company; and Mr. George W. Jackson, of Chicago, Ill., was appointed to consider the proposed method of operation. This committee examined the preliminary designs of the machinery, inspected the model and the experimental rope drive, and reported unanimously in approval of the proposed construction.

(To be continued.)

EXPLOSION OF A VULCANISING PAN.

A report has recently been issued by the Board of Trade, based on a preliminary inquiry, under the Boiler Explosions Acts, 1882 and 1890, and conducted by Mr. H. Cranwell, surveyor, with regard to the circumstances and cause of the explosion of a vulcanising pan on March 1, at the Sorbo Works, Woking, owned by Messrs. Sorbo Rubber Sponge, Limited. No person was killed, but Mr. S. I. Levy, assistant managing director, and Mr. J. H. Wakefield, charge hand, were both injured, but had recovered and resumed duty.

The report states that the pan was a cylindrical vessel 4 ft. in diameter by 5 ft. in length, internal dimensions. It consisted of inner and outer shells, made of steel plates, ¼ in. in thickness, riveted together at their ends through foundation rings, 2 in. in thickness, and stayed by means of 32 riveted stays arranged in two circumferential rows. One end was closed by a dished steel plate, ¾ in. in thickness, riveted to the shell, and at the other end a hinged steel door was held in position by 24 steel swing bolts, 1 in. in diameter, which engaged with slotted lugs riveted to the door. The vulcanising pan, as originally constructed, was a steam-jacketed drier, the name of the makers and the age of which are not known. In January last, the dished end and hinged door were fitted to meet the requirements of the present owners. The apparatus was inspected, after being converted into a vulcanising pan, by Mr. Bailey, at the Sorbo Works; and it was also examined by a representative of the Vulcan and General Boiler Insurance Company, with a view to insurance, but was not insured.

On the day of the explosion, after steam had been admitted about 15 minutes to the interior of the pan, the door was suddenly blown open without any previous warning. The cause of the failure was that no provision was made to retain the swing bolts in position when tightened up, the securing lugs of the door deflecting under the pressure of the bolts and the pressure in the interior of the pan, thus establishing a tendency for the bolts to slip from the slotted lugs. The outer ring of jointing material was apparently forced from its recess in the face of the door against the bolts, and disengaged them from the deflected lugs.

Mr. Cranwell, in his "general remarks," given in the report, goes at considerable length into the history and construction of the pan which, after passing through several hands, became the property of Mr. Davis, of Billiter-street, E.C., who converted it into a vulcaniser for the Messrs. Sorbo Company, in April, 1920, by fitting a steel door to the front end and riveting a steel dished end to the back of the vessel. It was then hydraulically tested in the presence of the engineer to a pressure of 120 lb. per square inch applied separately to the steam jacket and the interior of the pan. Subsequently the pan was installed at the Sorbo Works in the vulcanising shop and was supplied with steam reduced to 60 lb. per square inch from a boiler working at 90 lb. The steam jacket and the interior of the pan were tested with steam to a pressure of 60 lb. per square inch. At the owners' request the Vulcan Boiler Insurance Company examined the pan with a view to insurance before it was put into operation, but the company declined to grant a policy in respect of the pan, it is stated, on the grounds that the end plate had been welded, and might, in their opinion, be considered a source of danger if the pan were used at a steam pressure of 60 lb. per square inch. As it was intended to work the interior of the pan to a steam pressure of about 35 lb. per square inch, and the pan had previously withstood much higher pressures, the owners did not consider that the objection to the end having been welded was serious. They did, however, improve to some extent the security of the door when subjected to pressure, by fitting studs to each alternative pair of angle bars to which the swing bolts were attached, the angle bars having only been welded to the shell at Mr. Davis's works.

On March 1 steam was admitted to the steam jacket and the pressure was maintained at 60 lb. per square inch. At 10.40 a.m. the moulds which contained the material to be treated were placed in the interior of the pan, the door was closed and the securing nuts were tightened up by hand at 10.50 a.m. Steam was gradually admitted and at about 11.20 a.m. the door was suddenly blown open. The steam pressure in the interior of the pan at that time was 23 lb. per square inch.

Mr. Cranwell concludes his report by stating that in his opinion the explosion was due to the deflection of the lugs of the door under the load imposed by the securing bolts and the steam pressure in the interior of the pan, and to the fact that no provision was made to prevent the swing bolts from becoming disengaged from the door lugs.

Mr. Cranwell makes reference to the fact that the nature of the constituents of the material treated in the pan was such that, during the process, gas would be produced which, if mixed with a suitable proportion of air, would form an explosive mixture. The chemists concerned are, he states, investigating the chemical aspect of the case, and it is understood that the pan will not again be used for vulcanising rubber under the conditions which obtained at the time of the explosion.

In his "observations" attached to the report, Mr. Carlton, the surveyor-in-chief, says: "The circumstances in which this explosion occurred are somewhat unusual. The vessel had been altered to perform certain work, and had afterwards been hydraulically tested to 120 lb. pressure per square inch, and the process for which the vessel was intended was in operation for the second time when the cover was blown open, the steam pressure in the vessel at the time being only about 23 lb. per square inch by gauge. It appears that in the process in operation gas is evolved which, if mixed with air in certain proportions, forms an explosive mixture. As pointed out, however, it is difficult to see how ignition of the gas was effected. It may therefore be that the swing bolts holding the cover were not very securely held in place, or the joints became displaced and forced the bolts clear of the slots into which they engaged, but the evidence either way is not conclusive. Fortunately, the results of the explosion were not serious."

BRITISH ENGINEERING STANDARDS ASSOCIATION.

The British Engineering Standards Association held its third annual meeting on Thursday, the 14th ult., at the Institution of Civil Engineers, when the Chairman, Sir Archibald Denny, Bart., presented his annual report and made a review of the position.

He showed the vastness of the work undertaken by the Association and the economical manner in which it was carried out. There were now more than 1,500 engineers who gave their time and experience to this national work, often at great personal expense and inconvenience. Whilst, however, engineers generally took the keenest interest in the various problems submitted to the Association, the business community was not as impressed as it should be with the commercial value of standardisation, otherwise the Association would not have so much difficulty each year in raising the comparatively small sum required for this work, a work which is of great value to the trade and commerce of the country. Last year 15,000*l.* alone was expended, of which the industry of the country contributed about 10,000*l.*, the remainder being in the nature of grants from H.M. Treasury and the Indian and Dominion Governments. If there were only a stronger link between the engineering and the selling side of industry, those who held the purse strings would realise to a greater extent their privileges as well as their obligations, and so enable the Association adequately to cope with the increasing demands being made upon its organisation.

The Chairman emphasised the progress made in regard to the revision of the steel sections; the standardisation of railway materials, in which the Association was taking an active part with the cordial co-operation of the railway companies; the automobile work which was now completely reorganised; the work in connection with a British specification for girder bridges, so badly needed; the extensive programme of standardisation of details in the construction of ships and their machinery; the important development in electrical work; and also the difficulties surrounding the standardisation of aircraft materials and parts. He mentioned that the chemists and chemical engineers were now making use of the organisation and that the work was bound to have a beneficial effect on that branch of British trade. He also referred to the satisfactory working agreement arrived at with the various Research Association which would enhance the already cordial collaborations between those engaged in research and the Standards Organisation, the line of demarcation of which was sometimes none too easy to draw.

In regard to the work abroad, the Chairman said there were now 11 local committees actually at work; these committees were continually making valuable suggestions to the Home Committee, and from their vantage point of experience in local conditions were in a position to offer most welcome advice.

He also mentioned the question of international standardisation and the proposals which were to be put into effect in order, with proper safeguards, to assist in guiding along right lines the trend of international agreement in engineering matters generally.

A number of suggestions were made by those present, the more important of which were the advisability of giving greater publicity to the work of the Association and the question of assisting purchasers to ascertain without difficulty the names and addresses of manufacturers who were prepared to work to British standards. These suggestions will be considered by a Publicity Committee recently nominated.

CATALOGUES.

Steam Separator.—The Griscom-Russel Company, 90, West-street, New York, have sent us a descriptive catalogue of their steam separator.

Electric Lamps for Miners.—An interesting catalogue of electric hand lamps for miners has been issued by the General Electric Company, Limited, Magnet House, Kingsway, London, W.C.

Mechanical Draught.—Fans and chimneys, some of them on a very large scale, for forced or induced draught for boilers, furnaces, kilns, &c., are described in a catalogue received from Messrs. Simon-Carves, Limited, 20, Mount-street, Manchester.

X-Ray Apparatus.—Several catalogues dealing with apparatus and supplies for X-ray medical practice and containing useful descriptive matter in general terms, have reached us from Messrs. Watson and Sons, Limited, Parker-street, Kingsway, London, W.C. 2.

Cold-Rolled Steel Strip.—Messrs. Bruntons, of Musselburgh, who specialise in the manufacture of cold-rolled steel strip in all varieties of finish and in low and high carbon steel, send a descriptive catalogue with useful technical information relating to their products.

Miners' Lamps.—A descriptive catalogue of the Thor safety lamp comes from Messrs. Haslam and Stretton, Limited, 11, Windsor-place, Cardiff, who are the selling agents for it. In addition to the standard pattern for colliers, a bull's eye and a pocket pattern are made.

Motor Car Accessory.—A "glare guard" of tinted glass, to protect the eyes of a motor car driver from the glare from the headlights of an approaching car, is described in a small catalogue issued by Messrs. Brown Brothers, Limited, Great Eastern-street, London, E.C. 2.

Aluminium Working.—A neat loose-leaf pocket-book, containing a complete set of the information leaflets, on aluminium and its uses, noticed in these columns as they were issued, has been received from the British Aluminium Company, Limited, 109, Queen Victoria-street, London, E.C. 4.

Pneumatic Pick.—A pneumatic pick suitable for mining and quarrying, weighing 16 lb. exclusive of the tool, and capable of working at 1,350 blows per minute, is illustrated and described in a leaflet received from the Consolidated Pneumatic Tool Company, Limited, 170, Piccadilly, London, W. 1.

Gravity Conveyor.—A gravity conveyor for transporting boxes, parcels, &c., from higher to lower levels is described in a catalogue received from Messrs. Herbert Morris, Limited, Loughborough. The conveyors are supplied in various lengths, either straight or curved, and can be supported from above or from below.

Circuit Breakers.—Mr. George Ellison, Perry Bar, Birmingham, sends two new editions of catalogues; one of which relates to air break circuit breakers for pressures up to 650 volts, whilst the other deals with trailing cable sockets and plugs for use with those circuit breakers. These lists are well illustrated and contain full technical and commercial particulars and prices.

Air Compressors and Pumps.—The catalogue issued by Messrs. F. W. Brackett and Co., Limited, Colchester, is a strongly-bound book of over 100 pages, very fully and clearly illustrated and with descriptive text and full technical and commercial particulars of their products. The matter is divided into six sections, devoted to air compressors, dry-vacuum pumps, wet vacuum pumps, plunger pumps, centrifugal pumps and steam engines.

Milling Machines.—Milling machines with horizontal and vertical arbours are shown in a catalogue received from Messrs. Alfred Herbert, Limited, Coventry, together with the necessary equipment for a great variety of work. The machines are heavily built and are supplied with all accessories for rapid and accurate cutting. A pillar machine with automatic table feed suitable for light work is also shown. All the machines in this series are fitted with stepped pulley drive.

Electric Driving of Looms.—A booklet issued by the Metropolitan Vickers Electrical Company, Limited, Trafford Park, Manchester, describes the application of electric motors to looms. Each loom is operated by a separate motor, which is generally fixed to the floor, though in some cases it is mounted on the framework of the machine. A short belt drive seems to be preferred, though gear and chain drives are used, and a chain with leather vee blocks at intervals is sometimes employed. Facts regarding motors with characteristics suitable to the machines are given, and the wiring connections, switches and many other important matters are discussed.

Coal-Cutting Machine.—A catalogue giving a very fully illustrated description of the construction and operation of their coal-cutting machine comes from Messrs. Cowlishaw, Walker and Co. (1920), Limited, 14, Cockspur-street, London, S.W. 1, who have manufactured this, or similar type machines, for the last twenty years. The machines are driven by three-phase electric motors or by reciprocating or turbine air motors, and, of course, are mounted on trolleys so that they may travel and operate independently, except for the air or electrical connections. A long bar, with helically-mounted cutters projects from the machine and makes a shallow cut in the coal at the top or bottom or any part of the seam. The cutting motion is both rotary and reciprocating and the machine is suitable for either long-wall or roof and pillar method of working.

"ENGINEERING" ILLUSTRATED PATENT RECORD.

SELECTED ABSTRACTS OF RECENT PUBLISHED SPECIFICATIONS UNDER THE ACTS OF 1907 AND 1919.

The number of views given in the Specification Drawings is stated in each case; where none is mentioned the Specification is not illustrated.

Where inventions are communicated from abroad, the Names, &c., of the communicators are given in italics.

Copies of Specifications may be obtained at the Patent Office, Sales Branch, 25, Southampton Buildings, Chancery-lane, W.C., at the uniform price of 1s.

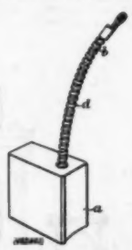
The date of the advertisement of the acceptance of a Complete Specification is, in each case, given after the abstract, unless the Patent has been sealed, when the word "Sealed" is appended. Any person may, at any time within two months from the date of the advertisement of the acceptance of a Complete Specification, give notice at the Patent Office of opposition to the grant of a Patent on any of the grounds mentioned in the Acts.

ELECTRICAL APPARATUS.

162,338. H. St. J. de A. Donisthorpe, London. Thermionic Valves. (2 *Figs.*) December 23, 1919.—In a thermionic valve of the three-electrode type for use in wireless telegraphy, a hemispherical plate electrode 4 and a grid electrode 7 are employed in combination with a straight or loop filament source

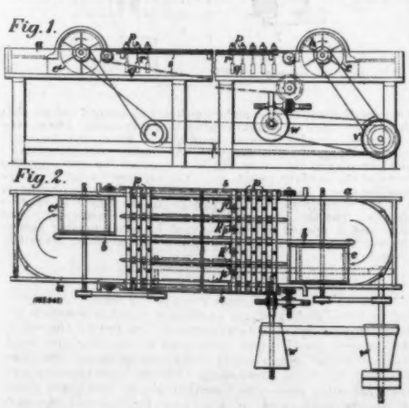
9 of the cathode stream. 1 is the vacuum vessel containing a glass pedestal 2 mounted in a holder 3. The hemispherical plate electrode 4 is supported by wires 5 sealed into the pedestal. Within the hemispherical electrode 4, the grid electrode 7 is supported by wires 8. The loop filament 9 is disposed as shown and connected by leading-in wires to two of the plugs. (*Accepted May* 11, 1921.)

162,461. W. W. Jarvis, Battersea, and The Morgan Crucible Company, Limited, Battersea. Carbon brushes. (1 *Fig.*) February 23, 1920.—To insulate the flexible copper conductor or pigtail *b* attached at one end to the brush *a* and at the other end to the brush holder, the insulation employed comprises a flexible openwork tube of a bore slightly larger than the



diameter of the pigtail *b* over which it loosely fits. The tube is composed of a strip of material *d*, such as vulcanised fibre or leatheroid, which is spirally wound into a flexible tube the bore of which is slightly larger than the diameter of the pigtail *b* over which it is passed and loosely fits. The tube may be made by softening the strip of material and winding it into a spiral on a mandrel. (*Sealed.*)

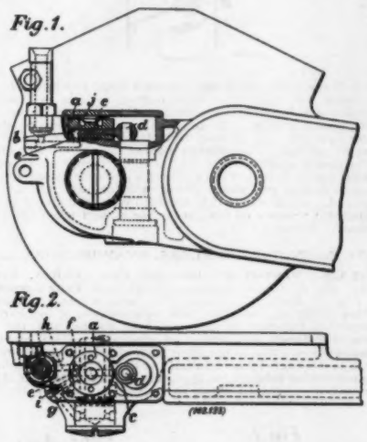
162,042. S. O. Cowper-Coles, Sunbury-on-Thames. Production of articles by electrolysis. (5 *Figs.*) January 16, 1920.—In a machine for the automatic and continuous production of seamless boxes, lamp sockets and other articles by electrolysis, the articles are produced on cathode moulds or



mandrels *q* of the required shape, which are fed by hand into one end of a trough *a* containing an electrolyte through which they are caused, by means of cone pulleys *v*, *w*, to travel at a speed which is variable according to the thickness of metal it is required to deposit on the cathodes to form the articles during the travel through the said trough, the cathodes with their metal deposit being then removed by hand. The trough *a* is divided into two main channels by a central partition *b* around which the electrolyte is caused to circulate by means of paddle wheels *c*, *c*1. The cathodes *q* are attached by means of a readily adjustable fitting to carrier bars *p*, which are then fed by hand on to slowly-moving endless chains *s*, which thus carry the cathodes through the length of the trough between the anodes through which an electric current of suitable density is supplied to the cathodes and returns by means of bus bars with which the carrier bars *p* are also in contact. The cathodes *q* are caused to rotate during their passage through the electrolyte by means of a star wheel *j* on each of their spindles *r*, designed to come in contact with fingers *k* at intervals along the trough. Instead of immediately removing the cathode carriers at the delivery end of the trough, an extension or platform may be provided to receive the carrier bars which are brought by the endless travelling chains *s*, and which may be left thereon to drain or dry. Or the endless travelling chains may be extended into and through a washing tank and into and through a third tank where the cathodes may receive a deposit of another metal on the metal that has already been deposited. (*Accepted May* 4, 1921.)

GAS ENGINES, PRODUCERS, HOLDERS, &c.

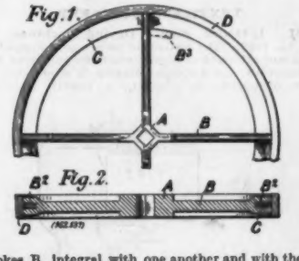
162,123. The Enfield Cycle Company, Limited, Redditch, and F. W. Smith, Redditch. Oil Pumps. (2 *Figs.*) February 12, 1920.—The oil pump for internal-combustion engines according to this invention is of the type in which the pump cylinder oscillates about an axis located transversely to the axis of the cylinder, and the pump cylinder is provided transversely within a barrel, the periphery of which forms the bearing surface permitting of the oscillation. The pump cylinder comprises a drum-shaped body *a* having a cylindrical periphery which enables it to oscillate within a correspondingly-shaped recess in the frame of the engine. A diametric cylindrical opening *b* is drilled in the drum-shaped body *a*, the opening functioning as the pump cylinder. In this cylinder a plunger *e* works, being operated by a crank-pin *d* driven from the timing gear of the engine. This crank-pin not only reciprocates the plunger *e*



within the pump cylinder, but also oscillates the drum-shaped body *a* in which the pump cylinder is drilled. At right angles to the pump cylinder and at the end remote from the crank-pin, a lateral port *e* is provided, and as a result of the oscillation of the body *a* this port is placed alternately into register with ingress and egress conduits *f*, *g*, drilled in the frame. These ingress and egress conduits are placed in communication with oil supply and delivery conduits *h*, *i*. The body *a* has a flat face which bears upon a corresponding flat bearing face provided in that part of the engine frame in relation to which the drum-shaped body operates, and the body *a* is retained in olitight relationship with this stationary face by a spring *j* located on the side of the body remote from that on which the said bearings face occurs. (*Sealed.*)

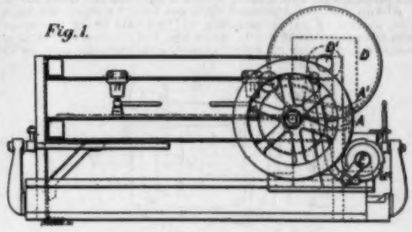
MACHINE AND OTHER TOOLS, SHAFTING, &c.

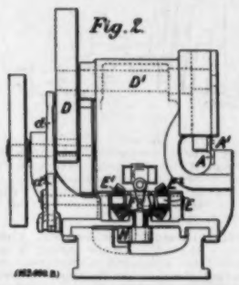
162,137. A. Bull, Attleborough. Pulleys. (2 *Figs.*) February 26, 1920.—In a wheel, belt pulley or brake drum of the kind in which the outer ends of the spokes are slotted and the slots engage a ring which may be the felly ring or part of the tyre, the centre comprises, according to this invention, four or



more spokes B, integral with one another and with the nave A, the ends of which are slotted at B^2 in the plane of the wheel to receive the continuous felly ring C. The tyre D may then be shrunk on to the felly ring. For fitting the felly ring into the slots B^2, the ends of two adjacent spokes may be heated and knocked down at one side B^3 of each slot. (*Sealed.*)

162,480. De Bergue and Co., Limited, Manchester, and A. H. Jackson, Manchester. Metal Plate Shearing Machines. (3 *Figs.*) March 6, 1920.—In a power-driven machine for shearing metal plates and strips of the type in which the shearing mechanism is mounted on a support upon which it can be traversed in a line parallel to the line of the shearing blades, and having a fixed bottom blade A and a vertically-moving top blade A^1, the traversing mechanism is, in accordance with this invention, driven from a wheel D on the main driving shaft D1, through a connecting rod *d*, one end of which drives a pawl

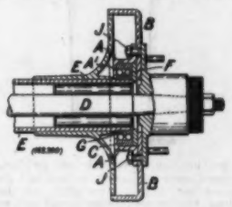




engaging teeth on a ratchet wheel d^2 mounted on a shaft E driving, through a reversing clutch F and bevel wheels E^1, E^2, a wheel engaging a rack H, or engaging a guide screw or a rotating nut engaging with a fixed guide screw. (*Sealed.*)

MOTOR ROAD VEHICLES.

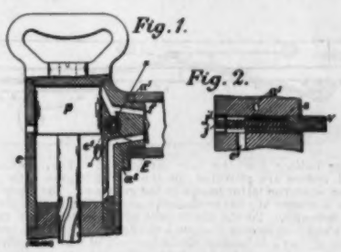
162,399. F. Bolton, Nottingham. Rear Axles. (2 *Figs.*) January 30, 1920.—For the purpose of adapting light motor car axles to carry heavy loads, of the kind in which a ball bearing is fitted between the fixed axle casing and a flange or housing bolted to the rear wheel, the housing A on the wheel for the ball bearing F is constructed so that the ball bearing is securely retained therein and is bodily drawn off the fixed axle casing together with the wheel when the latter is removed. The housing



A is secured to the brake drum B by means of bolts J, and this housing holds the outer main part C of the ball bearing F concentric with the live axle D on which the wheel is secured, whilst the end of the fixed axle casing E receives the inner sleeve part G of the ball bearing F on its exterior as is usual. The housing A is provided with an internal flange A^1 disposed on the inner side of the ball bearing F, so that when the wheel is removed this flange A^1 withdraws the whole of the ball bearing F, and retains it. (*Accepted May* 11, 1921.)

MINING, METALLURGY AND METAL-WORKING.

162,486. T. G. Nyborg, Hexham-on-Tyne, and M. F. Higgins, Sheffield. Percussive Rock Drills. (2 *Figs.*) March 15, 1920.—The improvements refer to a pneumatic percussive rock drill of the kind in which the cylinder *c* is provided with two admission ports c^1, c^2 situated at the ends of two passages leading from a pressure chest and two exhaust ports (of which only one, c^3, is visible on the drawings) situated centrally of the admission ports, the remote end of the admission passages being controlled by a flap valve *f*. The cylinder *c* has, according to this invention, the exhaust port c^3 appropriate to the return stroke of the piston *p* connected to a transverse



passage E in which is a supplementary valve *v*, the admission passage appropriate to the forward stroke of the piston *p* being also connected to the transverse passage E. The arrangement is such that in the normal position of the valve *v*, the exhaust passage is uncovered and the admission passage closed; on actuation of the valve, the exhaust passage is closed and the admission passage is opened directly to exhaust. The valve *v* is hollow, is closed at one end and is normally held in the position shown by a spring *s*; the valve is prevented from rotation by a pin, and the spring *s* abuts against a stop *j* provided with passages j^1. (*Sealed.*)

162,151. T. G. Nyborg, Hexham-on-Tyne. Percussive Drills. (3 *Figs.*) March 4, 1920.—The tool of a percussive drill is retained by a spiral spring 1 engaged on the muzzle-cap and formed with two eyes 2, in which are held the free ends of a stirrup member 3 formed with two eyes 3*a* separated by a bent portion 3*b* partly encircling the toolshaft so as to engage with the underside of a collar 8 thereon, and a two-armed locking member 4, one arm of which is passed through the eyes 3*a* in

Fig. 1.

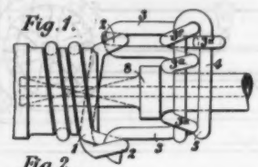
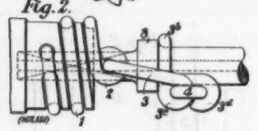
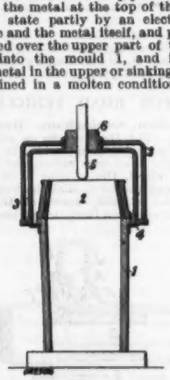


Fig. 2.



the stirrup member 3. The second arm of the locking member 4 is formed with a terminal projection 5 to snap behind one of the eyes 3*a*. One end of the stirrup 3 is extended axially to form two eyes 3*c*, 3*d*, to provide additional retaining means for the locking member 4, the eye 3*c* being in line with the two eyes 3*a* and the eye 3*d* receiving the second arm of the U-shaped locking member 4. (*Sealed.*)

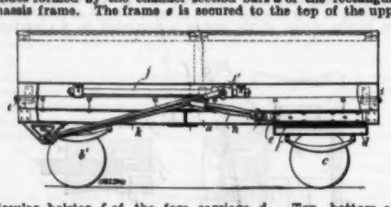
162,348. H. H. Hosack, Twickenham. Casting Metals. (1 *Fig.*) January 15, 1920.—In the casting of steel and other metals, to prevent the formation of pipes and cavities at the head of the casting, the metal at the top of the mould is maintained in a molten state partly by an electric arc produced between an electrode and the metal itself, and partly by means of a vacuum hood placed over the upper part of the mould. After the metal is cast into the mould 1, and it is filled to the required level, the metal in the upper or sinking-head portion 2 of the mould is maintained in a molten condition, more especially



in the central portion, by an electric arc produced between an electrode 5 disposed over its upper surface and the metal. The arc is maintained for such a time that, as the whole ingot shrinks in cooling, the upper molten metal can sink so that no or little cavitation takes place. The current is then cut off, and cooling takes place freely. The electrode 5 is passed through and fixed in an insulator 6 in the hood 3, the lower edge of which rests on the flange 4 on the mould exterior. The hood 3 is a hollow chamber having double walls with bright inner surfaces, and is exhausted of air. (*Sealed.*)

RAILWAYS AND TRAMWAYS.

162,374. H. C. Manley, Ainsdale, F. J. Brown, London, and G. C. Parker, London. Tipping Wagons. (3 *Figs.*) January 28, 1920.—The improvements refer to tipping wagons or trailers of the kind in which the tipping of the wagon body relatively to the chassis is effected by the backing of the tractive means. According to this invention, the fore-carriage is arranged to slide relatively to the chassis. The main chassis is in the form of a rectangular frame composed of channel section metal bars *a*, with a transverse or cross-bar at about the middle. This chassis is mounted upon the rear wheels *b*1 and front wheels *c*, which latter are carried by the fore-carriage *d*, which is furnished with the frame *e* designed to slide in lateral guides formed by the channel section bars *a* of the rectangular chassis frame. The frame *e* is secured to the top of the upper



circular bolster *f* of the fore carriage *d*. Top, bottom and lateral rollers are provided on the sliding frame *e* to reduce friction when the latter moves in the guides *a*. The body of the wagon is hinged at *i* to the chassis *a* at one side, so that it can be tilted laterally. To the lower part of the wagon body there is fixed a rod *j*, upon which slides a sleeve *j*1 to which one end of a connecting rod *k* is jointed, the other end of which is connected by a universal joint to brackets secured to the underpart of the chassis *a*. At a point intermediate its two ends, the connecting rod *k* has hinged to it one end of a link *n*, the other end of which is attached by a universal joint to the rear portion of the sliding frame *e* of the fore carriage. (*Accepted May* 11, 1921.)

SHIPS AND NAUTICAL APPLIANCES.

162,081. Harland and Wolff, Limited, Belfast, and R. G. L. McLennan, Belfast. Ships' Side Valves. (5 *Figs.*) January 19, 1920.—Apparatus operated by a fluid under pressure for closing, from a distance, openings in the side of a ship below the bulkhead deck, other than ash-ejection openings, simultaneously by means of cylinders and pistons at each ship's side valve, or sectionally by means of shut-off valves on branch pipes from the mains, comprises a force pump R communicating with a source of fluid supply O to supply fluid under pressure through a change cock N to a cylinder A supported relatively to the valve to be operated. The fluid pressure acts on the piston B in the cylinder A, and when applied to one end of the cylinder the piston is moved in one direction and through suitable connections is caused to close the ship's side valve C. When the fluid pressure is relieved by reversing the action of the

Fig. 1.

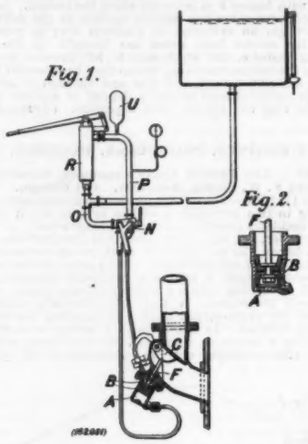


Fig. 2.

piston B, the means for closing the valve C can be withdrawn and the valve left free. The novel feature consists in that the diameter of a double-acting cylinder A is greater at one end of the piston B than at the other end, or in the case of single-acting cylinders and pistons, the diameter of one cylinder is greater than that of the other to prevent the ram F being forced to the closed position when fluid of equal pressure acts simultaneously at both ends of the cylinder A or on the pistons in both cylinders where two single acting cylinders and pistons are employed. An air vessel U is provided on the delivery pipe P to maintain pressure on the fluid in the system when the valve is closed. (*Sealed.*)

STEAM ENGINES. BOILERS, EVAPORATORS, &c.

162,525. Fawcett Preston and Co., Limited, Liverpool. (*H. W. Taylor, Phœnix, Mauritius.*) **Tube Scrapers.** (2 *Figs.*) April 15, 1920.—The tube scraper, according to this invention, comprises two separate sets of tool carriers 2 connected together by a connecting means, and the employment between the carriers of removable collars acting as distance pieces. 3 is an operating rod, which is connected to the pair of tool carriers by a removable or hinged joint connection 5. This connection between the operating rod 3 and the pair of tool carriers 2 is at a point between the two sets of tools 1 on the ends

Fig. 1.

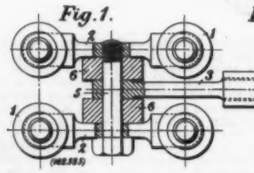
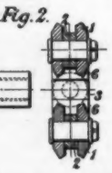


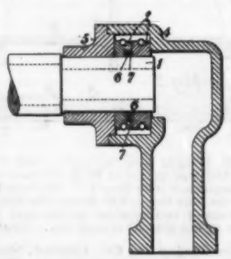
Fig. 2.



of the carriers. The carriers in some cases may be slightly flexible or of a springy nature, whereby they press the tools on to the scale on the interior of the tube, when the implement is inserted in the tube. The pairs of rollers 1 at each end of the carriers 2 are mounted on pins passed through them and the ends of the carriers. 5 is a screw stud spindle which secures the carriers 2 and interposed collars 6 together. By unscrewing the stud 5, removing the collars 6, substituting others of different width, and then re-inserting the stud again, the tools 1 on the two carriers may be spaced apart at different widths for operating in tubes of different size. (*Accepted May* 11, 1921.)

TEXTILE MACHINERY.

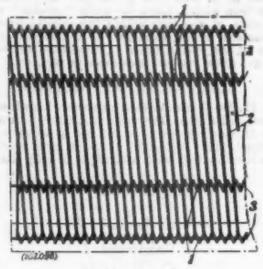
160,481. J. Ogden, Bury. Drying Machines. (3 *Figs.*) October 15, 1919.—The invention refers to doll-head bearings for the steam cylinders of drying machines employed for drying textile materials. A doll-head bearing in accordance with this invention, comprises two collars 2 tightly embracing the



trunnion 1 of the cylinder and having turned and trued faces which fit against turned and trued faces on the inside of the doll-head 4 and the stationary cap bearing 5. One of the collars is provided with recesses 7 which house springs 6, which impinge upon the other collar in order to take up wear. (*Sealed.*)

MISCELLANEOUS.

162,098. B. Bradley, London. Reinforced Concrete Pipes. (2 *Figs.*) January 28, 1920.—This invention has reference to the manufacture of reinforced concrete pipes provided with a circumferential reinforcement in the form of a wire helix 2. To ensure that the circumferential reinforcement is held in position, spacing members in the form of wire helices 1 of relatively small diameter are employed. A plurality of these spacing members 1 is arranged in a manner similar to that in which the longitudinal reinforcements hitherto employed are placed, and the circumferential reinforcement in the form of a wire helix 2 is so applied that the successive turns of the latter are engaged between adjacent turns of the helices 1 constituting the spacing members, a rod 3 inserted in each of the



latter serving to prevent the turns of the reinforcing helix being disengaged from the spacing members. In forming the reinforcing member, the spacing members 1 are secured in position on the drum or former about which the circumferential reinforcement 2 is wound, and after a complete helix of the wire constituting the latter has been applied to the drum in order to produce a reinforcing member of the desired length, a rod 3 is inserted in each of the spacing members, after which more wire may be wound thereon and secured in like manner, until the desired amount of wire has been wound about the drum. To facilitate securing the spacing members 1 in position on the drum, their ends may be bent to form loops adapted to be engaged by pins or projections provided on the drum or former. (*Sealed.*)

161,781. C. J. Hewens, Lewisham. Automatically Weighing Liquids. (6 *Figs.*) February 23, 1920.—Apparatus for the automatic weighing of liquid comprises a liquid controlling valve 1 and electromagnetic operating means therefor, a primary switch 11 which places the electromagnetic means in circuit at the commencement of the weighing operation, a normally-closed secondary switch 13 which is opened to place the electromagnetic means out of circuit at the completion of the weighing operation, and a tertiary switch 12 operated by the electromagnetic means and controlling said means so that they

Fig. 1.

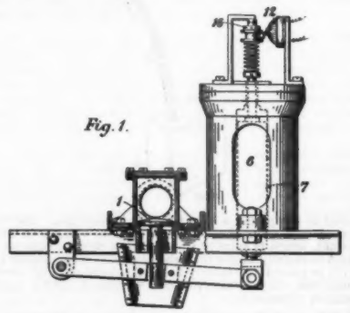
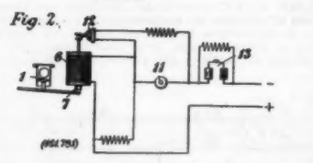


Fig. 2.



are operative until the secondary switch 13 is opened and are then inoperative until the primary switch is again closed. The electromagnetic operating means comprising a solenoid 6 having a core or plunger 7 connected with the liquid-controlling valve 1 and carrying a sleeve 16 which is engaged by the operating lever of the tertiary switch 12. The tertiary switch is of the tumbler type. The sleeve 16 is mounted on the core or plunger 7 of the solenoid so as to be capable of movement in relation thereto. The secondary switch 13 is of the normally closed type and is opened by the steelyard or other moving part of the weighing machine on completion of the weighing operation. (*Sealed.*)

Sweden's Trade Agreement with Spain.—According to *Swedish Export*, an exchange of notes between the Swedish and Spanish Governments has led to the result that a new provisional agreement concerning the regulation of the commercial relations between the two countries has been concluded. The Spanish Government undertakes to apply to Swedish goods the lower rates of duties contained in the new provisional Spanish customs tariff while the Swedish Government engages to accord most-favoured-nation treatment to Spanish goods imported into Sweden. The agreement has come into force as from June 21, and is to be valid during three months, and after that time until further notice has been given, the term of notification being one month.